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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 106. 7263

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See Advertisement page 74. 7208

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See Full Page Advt., page 78, April 4.

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See Advertisement page 86, April 11. 2402

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See Full Page Advertisement, April 4.

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See half-page Advert. last week and next week. 7526

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See half-page Advertisement page 95, April 18.

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ROYAL CORPS OF NAVAL CONSTRUCTORS.

A Competitive Examination for not less than one POST as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, towards the end of June next.
The Regulations and full particulars of the salary, prospects of promotion, etc., may be obtained from the SECRETARY, (C.M.) ADMIRALTY, Great George Street, S.W. 1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience not later than 15th May next.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.

In conjunction with the above examination, there will be a qualifying examination for the Admission of Private Students of Naval Architecture to the Royal Naval College, Greenwich. Applications for the regulations, etc., should be made as in the case of the examinations for the post of Probationary Assistant Constructors (see above).
Private Students are required to pay a fee of £30 a session whilst at the College. U 347

Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 7488

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TENDERS.

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY AND ERECTION OF TWO DIESEL ENGINES, GEARING, AND CENTRIFUGAL PUMPS FOR HAMPTON.

The Metropolitan Water Board invite

Tenders for the Supply and Erection of Two Diesel Engines, Gearing and Centrifugal Pumps at their station at Hampton-on-Thames. Forms of Tender, Conditions of Contract, Specification and Drawing, may be obtained at the Central Office of the Board, Chief Engineer's Department, South Place, Finsbury Pavement, E.C. 2, on and after THURSDAY, the 24th day of APRIL, 1919, on the production of an official receipt for the sum of £5, which sum must be deposited with the Board's Accountant, at South Place, Finsbury Pavement, and will be returned on receipt of a *bona fide* Tender with the incidental papers.
Such payments and application must be made between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve noon.)
The Tenders are to be delivered to the Board not later than 10 a.m. on MAY 22nd, 1919.

A. B. PILLING,
Clerk of the Board.

17th April, 1919.
South Place,
Finsbury Pavement, E.C. 2. U 300

COUNTY BOROUGH OF OLDHAM.

TRAMWAYS DEPARTMENT.

The Tramways Committee are prepared to receive

Tenders for the Supply and DELIVERY, at Glodwick Road Depot, of 100 TONS STEEL TRAMWAY RAILS, B.S. No. 4, in 60 ft. lengths, with the necessary Fish Plates.
Tenders, sealed and endorsed "Tender for Rails," must be delivered to W. CHAMBERLAIN, General Manager and Engineer, Wallshaw Depot, Oldham, not later than first post APRIL 29th, 1919.
The Committee do not bind themselves to accept the lowest or any Tender.

J. H. HALLSWORTH,
Town Clerk.

April 16th, 1919. U 297
April 7th, 1919.

Sale by Private Tender.

COMPLETE ALTERNATING CURRENT GENERATING PLANT consisting of:—
One 535 B.HP., and two 300 HP. Carels three-cylinder Diesel Oil Engines with Reavell Compressors, direct-coupled to
Two 218 K.W. and one 325 K.W. Dick Kerr 3-phase 2000 volt.
50 period Alternators with direct-coupled Exciters.
Complete Auxiliary Gear, consisting of Reavell 4-stage Compressor, driven by direct-coupled 2000 volt, 3-phase, 100 HP. Induction Motor. Marble Switchboard with mechanical remote control for three generator and two feeder panels with the usual measuring and synchronising gear. Motor-driven, water circulating and fuel oil pumps, Heenan & Froude Water Cooling Plant for 7000 gallons per hour. Cooling Water and Fuel Oil Tanks, Fuel Oil Storage Tanks of 90 tons capacity and quantity of new and second-hand Spare Parts.
Also One 20 ton Engine Room Crane, 47 ft. span, with hand traverse, and electric hoist; and One 15 ton ditto, hand traverse, hoist 37 ft. 6 in. span.
The whole is in good running order, and adjusted to run on either tar or crude oil.
The plant may be inspected by prospective purchasers by appointment.
Offers will be considered for the whole or part of above plant.—Address, U 32, Offices of ENGINEERING.

LONDON COUNTY COUNCIL.

Tenders are Invited for the supply of 5000 DRIVING WHEEL TYRES and 3500 TRAILING WHEEL TYRES for Electric Tramways.
The Form of Tender may be obtained from the General Manager, London County Council Tramways, 23, Belvedere Road, Lambeth, S.E. 1.
No Tender received at the County Hall, Spring Gardens, S.W., after 4 p.m. on Monday, the 12th May, 1919, will be considered.
The Council does not bind itself to accept any Tender.

JAMES BIRD,
Clerk of the London County Council. U 295

G. R.

BY DIRECTION OF THE DISPOSAL BOARD.

OILS FOR SALE BY PUBLIC TENDER.

Tenders are Invited for the following:—
1. 2000 gallons (in 40 gallon barrels) "Germexol" Antiseptic Cutting Oil.
This is lying at Sheffield.
2. 14,500 gallons Machinery Oil (100 gallons in 5 gallon drums, the remainder in 40 gallon barrels), with Specification as follows:—
   (a) F.P. — 327° F.
   (b) Viscosity = 140/99 secs.
   (c) S.G. — 933.
   (d) Acidity calculated as Oleic Acid = 35.
This is lying at Newcastle-on-Tyne.
Tender Forms, etc., may be obtained from the CONTROLLER, D.B. 5a, 37-41, Old Queen Street, Westminster, S.W. 1.
Telegrams: "Explicoma, Parl, London."
Telephone: Victoria, 8420; Ext. 218. U 287

G. R.

BY DIRECTION OF THE DISPOSAL BOARD.

NATIONAL PROJECTILE FACTORY, TEMPLEBOROUGH, SHEFFIELD.

For Sale by Tender this FREEHOLD FACTORY.
The following is a brief description:—
Situation.—Fronting Main Road and Electric Tram Route from Sheffield to Rotherham.
Within the City of Sheffield, ¾ mile of Tinsley Station, G.C. Rly.
Construction.—The Main Engineering Shop is steel framed with corrugated iron walls, roof part glazed and part corrugated iron. Floor of wood and concrete; length 560 feet, width 400 feet, height 20 feet in the clear. Electric cranes either side of building, area, 234,000 super feet.
Bond Room attached, area 32,340 super feet.
Main Offices, Slab Walls, covered ruberoid, area 8376 super feet.
Main Store, Steel framed, covered corrugated iron, area 5945 super feet.
Mill Wrights Shop, Stores, Power House, Boiler House, etc.
Additional Buildings, Timber built with corrugated iron walls and corrugated iron or ruberoid roof, comprises:—
Canteen and Lavatories, area 26,823 super feet.
Cloak Room, area 10,560 super feet.
Tool Room, Small Store, Ambulance and Surgery, Garage, Men's and Women's Time Office (Brick built) Lorry Shed, Staff Lunch Room, etc.
Total ground area of buildings, 355,519 super feet.
The Factory was erected by the Government in 1915-16, and has been used for Shell Making.
Area of Land.—30 acres (about) giving large area for extension.
Power and Lighting.—Electric (Corporation Mains).
Heating.—Steam.
Water.—Public Main.
Sidings.—Full gauge connection with the G.C. Railway. Total length 4565 feet.
Office Accommodation for 209 clerks.
Mess Room Accommodation for 1500 persons.
Forms of Tender may be obtained from the DISPOSAL BOARD, Factories Section, Charing Cross Buildings, Embankment, London, W.C. 2. U 282

APPOINTMENTS OPEN.

CITY OF BIRMINGHAM EDUCATION COMMITTEE.

JUNIOR DAY TECHNICAL (ENGINEERING) SCHOOL.

The Education Committee invite

Applications for the Post of HEAD MASTER of the above School, to be opened about September next. Candidates must have had experience in teaching and in General Engineering. The maximum salary for the post is fixed at £650 per annum. The commencing salary will be determined by qualifications and experience, with a minimum of £400 per annum. Forms of application may be obtained from the undersigned, and should be returned not later than the 13th MAY.
—JNO. ARTHUR PALMER, Secretary of Education, Council House, Margaret Street, Birmingham. U 293

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc. (Hons.), London, A.R.C.Sc., London, Principal.

Applications are Invited for the Post of LECTURER in Mechanical Engineering, at a commencing salary of £250 per annum, with increments of £25 per annum up to £300, subject to satisfactory service.
Applicants should possess the degree of a University in the United Kingdom, or hold equivalent qualifications. Applications, together with not less than three recent testimonials should be submitted before MAY 12th, to the PRINCIPAL, from whom Forms of Application and any further particulars may be obtained.

W. A. BROCKINGTON, O.B.E., M.A.,
Director of Education. U 325

A Large Firm of Engineers in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of ENGINEERING.

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc. (Hons.), LONDON, A.R.C.Sc., LONDON, PRINCIPAL.

Applications are Invited for the POST of RESPONSIBLE HEAD of the Evening Departments of the College. Applicants should possess the degree of a University in the United Kingdom or hold equivalent qualifications.
Salary £300 per annum, rising by annual increments of £10 to £350. Applications, together with not less than three recent testimonials, should be submitted before May 12th to the PRINCIPAL, from whom Forms of Application and any further particulars may be obtained.

W. A. BROCKINGTON, O.B.E., M.A.,
Director of Education. U 322

CITY OF ABERDEEN.

WATER ENGINEER.

The Town Council of Aberdeen are prepared to receive

Applications for the Appointment of WATER ENGINEER.
Commencing salary, £600 per annum.
Applicants are requested to state their age, and experience in designing, constructing, and carrying out waterworks.
The successful applicant will have to devote his whole time and attention to the duties connected with the appointment.
Applications, accompanied by copies of testimonials, and endorsed "Water Engineer" to be lodged with the undersigned not later than SATURDAY, the 3rd proximo.
A memorandum of the duties may be had (on application) from the Town Clerk.

W. GORDON, Town Clerk.

Townhouse, Aberdeen,
9th April, 1919. U 319

CITY OF BIRMINGHAM WATER DEPARTMENT.

APPOINTMENT OF CHIEF INSPECTOR.

Applications are Invited for the above-named POSITION. The person appointed must have thorough and practical knowledge of the plumbing trade, and of all classes of water pipes and fittings. He must be capable of
(A) Advising water consumers and plumbers as to the installation of pipes and fittings;
(B) measuring up work; and
(C) preparing estimates of cost of laying cast-iron and lead service pipes, and of fixing meters.
He will also be required to make agreements for supplies and to arrange terms for special uses of water.
Salary £250 per annum with war allowance £92.
Applications, stating age, qualifications and experience, with not more than three recent testimonials, must be marked "Chief Inspector" and be sent in, addressed to the undersigned, not later than 14th May, 1919.

E. ANTONY LEES, Secretary,
City of Birmingham Water
Council House, Department.
Edmund Street,
Birmingham. U 300

COUNTY BOROUGH OF CROYDON.

EDUCATION COMMITTEE.

The Committee invite

Applications for the Post of PRINCIPAL of the Polytechnics.
The salary commences at £500 per annum and rises to £600 by annual increments of £25. The appointment will be subject to termination by three months' notice on either side at any time.
Candidates must have a British University Degree. The candidate appointed will be required to devote the whole of his time to the duties of his office, and will be responsible for the development, organisation, co-ordination, discipline and educational efficiency of the Croydon Polytechnics and Continuation Schools.
The Courses of Instruction in the Polytechnics include Science, Mechanical and Electrical Engineering, Building and other Trades, Domestic Subjects, and Commercial and Language Classes.
Applications, accompanied by copies of not more than three testimonials of recent date, must be sent to the undersigned not later than Saturday, 10th May, 1919.
Canvassing members of the Committee will disqualify any candidate.

JAMES SMYTH,
Clerk to the Committee.

Education Office,
Katharine Street,
Croydon.
16th April, 1919. U 301

BOROUGH POLYTECHNIC INSTITUTE, BOROUGH ROAD, LONDON, S.E. 1.

The Governing Body will

Require Shortly to fill Positions now held by Temporary Staff, in the Day Technical School and Evening Class Department.
1. LECTURER in Electrotechnics Department
2. LECTURER in the Mechanical Engineering Department.
3. LECTURER in the Chemistry Department.
4. TEACHER of Mathematics.
5. TEACHER of English Subjects.
6. SUPERINTENDENT of Workshops, able to lecture on Workshop Practice.

Candidates for these appointments should have had good teaching experience and possess a good University degree or its equivalent; but this latter qualification will not be insisted upon in the case of persons otherwise exceptionally qualified.
For appointments 1, 2 and 6, good works experience and ability to carry out laboratory demonstrations are essential.
The commencing salary for each appointment will be £240 per annum and war bonus according to L.C.C. Scale, rising by annual increments of £15 to £360, and £10 to £400.
Particulars of each post and form of application may be obtained by sending stamped addressed foolscap envelope to the undersigned.
Applications must be received not later than 3rd May. U 69

C. T. MILLIS, Principal.

DONCASTER JUNIOR TECHNICAL SCHOOL.

Wanted, Two Full-time TEACHERS, one qualified in Metal Work and allied subjects, and the other qualified in Mathematics and English. Salaries according to scale.—Full particulars, and Application Forms, may be obtained from, J. BAGLES, A.R.C.Sc., Principal, Technical College, Doncaster. U 318

ROYAL AIR FORCE.

TEMPORARY EDUCATIONAL APPOINTMENTS.

The Services of 30 Teachers are REQUIRED for duty in the Royal Air Force Training Establishments for Boy Mechanics.
Candidates should be qualified to give instruction in some or all of the following subjects:—
Practical Mathematics.
Applied Mechanics.
General Elementary Science.
Mechanical Drawing,
English and Civics.
Salary at the rate of £250 per annum.
Applications, together with copies of not more than three recent testimonials and a statement of age, educational training, qualifications and experience, should be forwarded to the
SECRETARY, AIR MINISTRY, Strand, W.C. 2, on or before 30th April, 1919. T 266

THE COMMISSIONERS FOR THE PORT OF CALCUTTA.

VACANCY IN ENGINEERING ESTABLISHMENT

The Commissioners require the

Services of an Assistant Civil ENGINEER, with experience in Dock and Harbour Works. The salary offered is Rs. 600 per month, rising by increments of Rs. 50 per month each year to a maximum of Rs. 700 per month, without free quarters. A first-class passage will be paid by the Commissioners.
Candidates should be about 30 years of age and preference will be given to those who hold a degree in Engineering, or belong to the Institution of Civil Engineers.
All applications must be made on forms which will be supplied to intending candidates by the London Agent—

Mr. J. ANGUS, M.Inst.C.E., U 234
17, Victoria Street, Westminster, S.W. 1.

Overseers Required by the Government of Hong Kong for the PUBLIC WORKS DEPARTMENT for a period of three years, with possible extension. Salary £200, rising to £230. Free passage and unfurnished quarters. Aged 25—30, unmarried.
Candidates should be:—Experienced in modern road construction, all branches, including asphaltic surfacing, tar paving, sett paving and general maintenance under a Borough Engineer, capable of measuring up and preparing statements of work done; or be:—
Experienced in carrying out good class constructional and painting work, qualified to take out quantities, including measuring up and preparing estimates of cost, with practical training preferably as carpenters.
Apply by letter, stating age and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1. U 287

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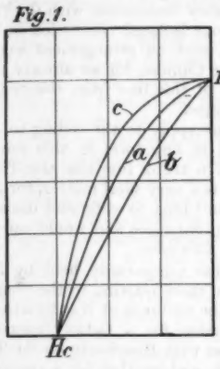
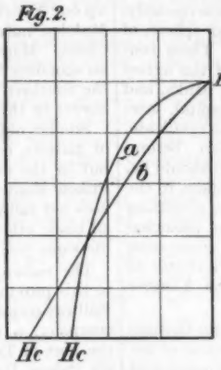
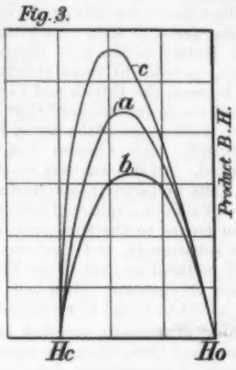
NOTE ON THE TESTING OF PERMANENT MAGNETS.

By J. D. MORGAN.

THE establishment in this country during the period of the war of a large magneto industry which has been accompanied by severe demands on the metallurgical skill of magnet makers, has stimulated a new interest in the properties of permanent magnets. Among the problems that have been reviewed are those of testing. Ordinarily a permanent magnet is tested by measuring first the magnetism which remains after magnetisation and then the coercive force required to neutralise the remanent magnetism. When a magnet is ordered for a particular duty the test is specified in terms of B_{rem} and H_c. Certain tolerances are usually allowed in both figures, but to ensure a satisfactory average a particular product of B_{rem} and H_c is also sometimes specified. Experience in the construction of ignition magnetos for internal-combustion engines proves that a specification of these two figures alone is insufficient to ensure the production of the best magnets. The reason for this is at once apparent from an inspection of Fig. 1. Here is shown at *a* a typical curve obtained in the demagnetising of a magnet giving specified values of B_{rem} and H_c. On the same diagram are given two hypothetical curves *b* and *c* having the same values at their extremities as the curve *a*. It is evident, and experience confirms, that a magnet corresponding to the line *a* would be better in service than the magnet corresponding to the line *b*; and likewise a magnet giving the line *c* would be better than one giving the line *a*. Yet all three comply with the specification. In the development of permanent magnets for magnetos insistent demands have been made for the highest possible values of H_c. But it has not been proved that any corresponding advantage is always gained by increasing H_c beyond certain limits. In fact, there is good reason for believing that some magnets having a relatively low H_c give as good a performance in practice as others having the same B_{rem} but higher H_c. Consequently, there has emerged the opinion that the slope of the curve at B_{rem} is an important index of the quality of the magnet and that a small slope is not necessarily accompanied by a high value of H_c. Accordingly, the requirement is sometimes made that the magnet must show a specified intermediate value of B when a specified demagnetising force H is applied. Professor Crapper in a recent important *resumé* of the technics of permanent magnets (ENGINEERING, October 4, 1918), draws attention to this requirement and refers to its arbitrary character.







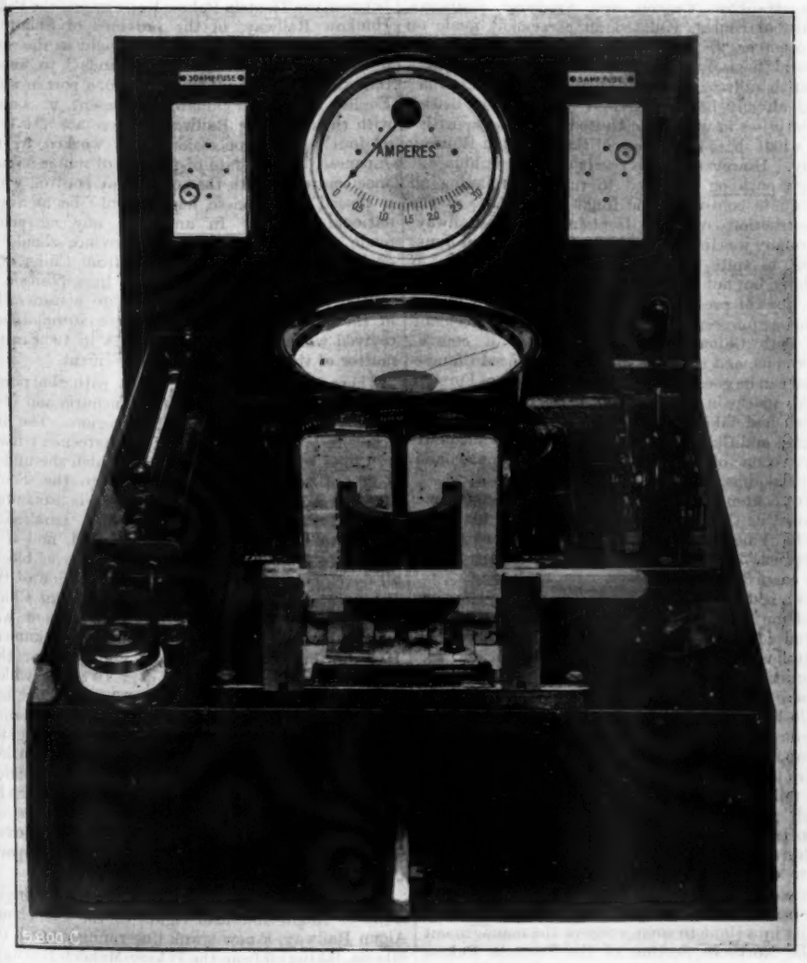
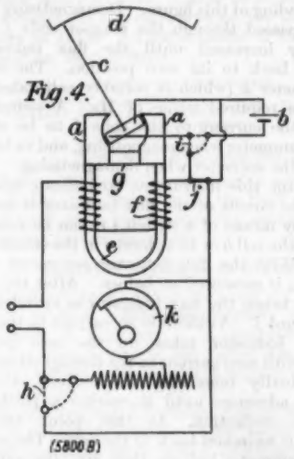


FIG. 5.

It must be admitted that there is a good deal of justification for the specification of an intermediate value of B for a particular value of H, and it certainly appears that too much insistence on increasing values of H_c may conceivably give a wrong direction to the future metallurgical development of permanent magnet steels. In the opinion of the writer a magnet giving a demagnetising curve of the form shown at *a*, Fig. 2, is a better magnet than one giving the curve *b*, which, notwithstanding its higher coercivity, has a greater initial slope at B_{rem}.

In the course of certain investigations on the properties of permanent magnets for magnetos the writer in conjunction with Mr. H. W. F. Ireland, endeavoured to find a more satisfactory additional test. They feel that in the present state of the art it is undesirable to depart from the established practice of specifying B_{rem} and H_c, but that there is also required a third figure which can be obtained in a convenient manner, and is not so open to the objection of being arbitrary as the third figure above mentioned. Their proposal will be readily understood from the following. It is evident that the three curves shown in Fig. 1 can be distinguished by the product of intermediate values of B and H, which gives a maximum figure. In Fig. 3 is shown the variation of the product of B and H between the limits H_o and H_c for each of the curves in Fig. 1, the curves in Fig. 3 being identified by the same reference letters as those used in Fig. 1.

To show how this maximum product can easily be obtained it is necessary to describe a magnet-testing instrument of well-known type which is readily adaptable to give the three figures above mentioned. Referring to the diagram in Fig. 4, a pair of pole-pieces *a* have pivoted between them a moving coil which is supplied with current from a cell *b*, providing a constant E.M.F. To the coil is attached an index *c* movable over a scale *d*. This serves as a flux indicator. In conjunction with the pole-pieces is arranged the horseshoe magnet *e* to be tested. The limbs of the magnet are slipped



through a pair of magnetising and demagnetising coils *f*. When magnetising, a keeper *g* is pushed into position between the pole-pieces, and magnetising current is supplied to the coils from a battery or generator. After interrupting the current the keeper is removed and current is passed through the flux indicator. The deflection is proportional to B_{rem}, and the scale *d* can be calibrated to give a direct reading of this figure. Demagnetising current is now passed through the magnet coils *f* and is gradually increased until the flux indicator is brought back to its zero position. The index of the ammeter *k* (which is suitably calibrated) then gives the required value of H_c. A switch at *h* enables the current to the coils *f* to be shunted past the ammeter when magnetising, and to be taken through the ammeter when demagnetising.

To adapt this instrument to indicate also B H (max.) the circuit of the flux indicator is arranged so that by means of a switch *i* it can be connected either to the cell *b* or to a shunt *j* in the circuit of the coils *f*. With the flux indicator connected to the cell, B_{rem} is measured as before. After this figure has been taken the flux indicator is switched over to the shunt *j*. As there is no current in the shunt the flux indicator takes up the zero position. Starting with zero current in the demagnetising coils and gradually increasing the current, the flux indicator advances until it reaches a position of maximum deflection. At this point the flux indicator is switched back to the cell. The moving coil and ammeter indexes then give the values of B and H whose product is a maximum. To obtain H_c the test is continued as already described. With the aid of such an instrument the values of B_{rem} H_c and B H (max.) can be very quickly obtained. The accompanying reproduction of a photograph, Fig. 5, shows an instrument designed by Mr. Ireland for the testing of magneto magnets in accordance with our proposal.

CHINESE QUESTIONS AND THE PEACE CONFERENCE.

THE present article is an attempt to draw attention to questions which may be of great future importance to the engineering trades of Great Britain—questions which have, up to date, been neglected largely perhaps because of the small relative importance of our trade with China, also because it was to German interest that national interest in things Chinese should not be aroused, and further because our Chinese finance was largely under German control before the war.

The questions above referred to naturally divide themselves into those which were purely German before the war but have now, to some extent, become Japanese, and those which are purely Japanese, for Russia has ceased to be a factor in Far Eastern politics except as a menace of disorder. In order to indicate the present position it will be necessary to summarise our railway policy in China since 1898. In that year was formed the British and Chinese Corporation, an association between the Hong Kong and Shanghai Bank and the great merchant firm of Jardine, Matheson and Co., of Shanghai. This association was to finance the various concessions obtained by Britain after the Boxer trouble, and has always had, owing to Foreign Office apathy, a complete monopoly of Government support. Up to the year 1905, purely Chinese affairs were dealt with entirely by Jardine, Matheson and Son, the bank confining itself to the financial side of the business and eschewing politics. From that year the policy of the bank underwent a complete change, as under the direction of the London office, it embarked on the business of political finance, and from that dates the decline of British power in China. That this was due to German influence is without doubt, for the association of the German-Asiatic Bank and the Hong Kong Bank has always been a close one, and at the date referred to evidently became closer for all the national and imperial character of the corporation, which existed before, vanished, to become cosmopolitan, if not pro-German in character. It is a significant fact that in 1912 four Germans were directors of the Hong Kong Bank, of whom one—Sir Carl Meyer, Bart.—was also a director, associated with the since notorious M. Caillaux, of the Chinese Central Railways,* a concern in which British interest was very large. Also in 1895 the Hong Kong Bank entered into an agreement with the German Asiatic Bank to share all Chinese Government business obtained by either party. In 1898, at the time of the demarcation of spheres of influence which defined our position in the Yangtse Valley—alas, for a very short time—five railway concessions necessarily, from the above, as they were within our sphere, of purely British origin, were obtained. These concessions, in order to avoid violation of the agreement between the British and German banks, and to avoid the introduction of German capital, were obtained in the name of the purely British syndicate, the British and Chinese Corporation before-mentioned. All this was very much as it should be, but in 1898 we tacitly abandoned our claim to the Yangtse Valley as a sphere of influence by admitting German troops to the protection of the Shanghai foreign settlements, and Germany, on evacuation in 1902, notified us that Great Britain's claims to influence or economic advantage in the Yangtse Valley would no longer be recognised.

Nothing of moment occurred in Anglo-German relations until 1908, when the representative of the German bank demanded a share in the financing of the Hankow, Canton and Szechuan Railways. This, of course, violated an agreement made on September 2, 1898, whereby German financiers bound themselves to respect the Yangtse Valley as a British railway sphere. Further, both these lines had already been recognised by China as British enterprises in which the United States was entitled to a half share in the case of the Szechuan Railway only. However, as the result of giving China one more push on the road to ruin, by relaxing all adequate control of the funds in the case of the construction of the Tientsin Pukow Railway, Germany was in high favour in Peking, and in June, 1909, in spite of strenuous British opposition in Peking, but not in London, obtained what she asked. Our loss of prestige in China, as the result of our tame acquiescence in the violation of agreement by both China and Germany, was, of course, enormous, and its effect on the ill-balanced Chinese mind can be guessed. This was the result of Foreign Office apathy in not appreciating the radical changes which had taken place in the constitution of the British and Chinese Corporation, and in inadequate supervision of finance which should have had imperial aims.

Not content with this, Germany at the same time notified us that she intended to compete for loans in the Yangtse Valley and elsewhere unless the agreement of 1895 for equality and participation was carried out in all cases.

As a result of this our concession for the Hankow Szechuan Railway was utterly lost and is at present shared equally by French, German and American capitalists. The rights of the Americans are unquestioned, those of France also by virtue of the Chinese Central Railways agreement of 1898 and the Anglo-French Convention of 1896 relating to the provinces of Szechuan and Yunnan, but Germany has no shadow of right, and these rights should now revert to us. This line as planned has a length of 750 miles, of which the British third share, on which practically nothing has been done, should be insisted on.

This disposes of the most burning question relating to Germany and the Yangtse Valley, and we now come to the after-War status of German pretensions in Shantung Province. Shortly, they consist in a right to some voice in the management of the Northern Section of the Tientsin Pukow Railway, constructed by Germans and with German capital in 1908–1911. It is, of course, most probable that China will try and cancel her obligations under the loan agreement for this railway as part of the terms of peace, but the Chinese are bound by an agreement with Japan to agree with whatever terms Japan may make with Germany with regard to this province. This will probably mean that the management of this railway would eventually drift into Japanese hands, and this should be prevented at all costs, for Japan's actions in Manchuria and elsewhere have shown a serious disregard for agreements or treaties and make it certain that Shantung will become as much a Japanese possession as Manchuria now is. Further, if any foreign power is to control this line it should be Great Britain, for it is obviously of the greatest importance to link up our Yangtse valley concessions with the Peking-Mukden railway, our isolated concession in North China. Moreover, such an arrangement would be an economy for the Chinese, for we already control the southern part of this line from the Shantung border to the Yangtse.

Similar objections apply to the ceding to Japan of railway control in any form in this province, but in the case of a trunk line like the Tientsin Pukow Railway it is a very vital matter, for Japan uses her railways in China to stifle and discourage all trade other than Japanese and would carry out the same policy in this case.

The railway rights temporarily held by Japan in this province are those relating to the Shantung Railway owned at the outbreak of War by a German company, a concession for a railway connecting the port of Tsingtau with Hsuchoufu on the Tientsin Pukow Railway, and another for a connection between the Tientsin Pukow Railway and the Peking Hankow Railway, in the province of Shantung. In addition, Japan has the prior right as the result of the illegal "twenty-one demands" to finance the railway to be built from Chefoo, a port in which English trade predominates at present, to connect with the Shantung Railway. There are also three or four mining concessions now worked by the Japanese, but the fate of these is of minor importance compared with that of railway control, which if placed in Japanese hands would be an international disaster. In any case any agreement made with China about this province should be declared void as it was wrung from China at a time when the Powers were not in a position to protest. Further, British claims to consideration in the province of Shantung were automatically revived when Germany broke faith in 1909 in the matter of the Yangtse Valley agreement.

There now remain to be dealt with the purely Japanese questions relating to Manchuria and their bearing on British rights in that region. The first necessity is the annulment of the agreement made by China with Japan in 1905, by which she undertook not to build a line parallel to the South Manchuria Railway. This agreement is a manifest absurdity as no distance at which parallelism ceased to be harmful was ever stated, and if it applies to Manchuria only, then it for ever blocks all development on the Manchurian portion of the Peking Mukden Railway for which we lent China £2,300,000 in 1899. This absurd agreement was responsible for the abandonment of the Fakumen-Hsinmin Fu Railway in 1908, and also for the further agreement with Japan in 1909, by which China undertook not to build this line without her consent. Here, again, is another glaring instance of Foreign Office failure to champion British rights. The attitude of the British and Chinese Corporation is equally inexplicable, and makes one wonder whether similar reasons which made it powerless in the case of the Szechuan Railway loans were at work here. At any rate the British attitude over this was one of grovelling acquiescence to Japan, which, of course, set a bad example to China.

The next point to be considered is the infringement of Anglo-American rights in the Chinchou-Aigun Railway, a new trunk line running north to Siberia, taking off from the Peking-Mukden Railway at a point about 110 miles East of the Great Wall. Altogether with its branches to the South Manchuria and Chinese Eastern Railways this line would have a length of 800 miles. For this line an agreement was signed between the Chinese Government and a British American Syndicate in 1910, but Japanese and Russian opposition prevented any further steps.

This agreement was violated by Japan when she constructed the Shihpingkai Railway in 1918, and by the proposal to extend this to Taonanfu, a city on the route of the proposed Aigun line. In point

* An Anglo-French concern formed in 1898 for the purpose of undertaking railway and finance business north of the Yangtse.

of fact a branch from Taonanfu to Changchun, the junction of the South Manchuria and Chinese Eastern Railways, was part of the American-British scheme. In addition to this Japanese rights to railway concessions in Eastern Inner Mongolia should be opposed, as they not only violate the above agreement but in some cases tap country which would naturally be developed by the Peking-Mukden Railway.

Lastly, the treaty which followed the presentation of the "twenty-one demands" by Japan to China, in January, 1918, should be declared void, as it was extracted from China when the Great Powers were unable to protest. The most objectionable clause from a trade point of view was the extension of the 25-year lease of the South Manchuria Railway for a further 99 years, and that relating to the management of the Kirin Changchun Railway, which was Chinese property. As previously stated, the Japanese control of a railway implies a Japanese trade monopoly, and the stifling of all legitimate competition. No better instance of Japanese methods could be given than the present condition of Changchun station, the terminus of the South Manchuria Railway, and its junction with the Chinese Eastern Railway. Here lie 13,000 tons of goods, stacked in the open, consigned to allied merchants trading in Siberia, and no attempt has been made or will be made by the Japanese to get rid of this accumulation, as Japanese products for the Siberian trade naturally take up all available space; in many cases it is said they are actually forwarded under the guise of supplies for the Japanese expeditionary force in Siberia. Other nationalities applying for cars must either pay an enormous bribe or go without.

This is typical of Japanese interpretation of the clauses in the Treaty of Portsmouth made with Russia in 1905, whereby the Open Door in Manchuria was guaranteed and also China's sovereignty in that region. These clauses we may quote as they need recalling, for now if ever is the opportunity to rehabilitate lost prestige in Eastern eyes and to show Japan that treaties are not mere scraps of paper. The clauses are as follows:—

"The Russian Government declare that they have not in Manchuria any territorial advantages or preferential or exclusive concessions in impairment of Chinese sovereignty or inconsistent with the principle of equal opportunity."

"Japan and Russia reciprocally undertake not to obstruct any general measures, *common to all countries*, which China may take for the development of the commerce and industry of Manchuria."

"Japan and Russia engage to exploit their respective railways in Manchuria exclusively for commercial and industrial purposes and in no wise for strategic purposes."

In the light of the above clauses Russia and Japan need calling to account for obstruction to the Chinchou Aigun Railway scheme, and Japan for the illegal and absurd agreement of 1905 with regard to the building of railways parallel to her own in Manchuria, which was responsible for the abandonment of the British Fakumen Railway in 1908. Lastly, Japan should be at once requested to immediately put a stop to the morphia and cocaine traffic in which her nationals are engaged, and which is becoming far more of a menace in China than opium ever was, for China has no authority over Japanese subjects, and there is no justice in Japanese consular courts, so that she is powerless to prevent the debauching of her people.

The question of Japanese loans to China contracted since the war is another point of vital interest to the British engineering trades. It is estimated that the amount lent to China by Japan during the war varies from £16,000,000 to £20,000,000, making her, after Great Britain, China's biggest creditor. With this money, made out of the Allies in munition manufacture and the capture of allied trade and shipping, Japan unquestionably financed, even if she did not foster, the wasteful civil war between North and South China, for the whole of this money was lent without any stipulation as to supervision of expenditure and with the knowledge that the money would not be used for its ostensible purpose. For this accommodation the Chinese patriot in Peking pledged the country's railway and mineral assets. It is probably too late to do much in the case of many of these loans, but Japan should be given to understand that mineral rights acquired by this means in British spheres of influence will be considered void, and further, that preferential rights to supply various Chinese railways and departments acquired in the same manner will also be ignored as contrary to the principles of the Open Door to which she has subscribed. It should be further intimated that concerns in which British capital is interested cannot be given as security for Japanese loans. Among the more objectionable of the loans contracted from a trade point of view are the Telegraph loan, which gives Japan control of all supplies and construction for the government telegraphs and telephones, and several other loans for which shares in the Kailan Mining Administration, Peking-Mukden Railway, were given as security.

Lastly, China herself should be asked to put her house in order, that is, to immediately stop the Civil War which has made her a vassal state of Japan and brought her to a state of chaos and misery never equalled in all her chequered history. Further, she should be required to disband much of her ill-disciplined and unruly army, and to curb the powers of the military clique who now virtually rule the country. This last is a very real need, as the government is at present losing an enormous revenue by useless troop movements which tie up the railways for days at a time. Further, travelling on such lines as the Peking-Hankow and the Tiensin-Pukow Railways has become unsafe, for both the foreigner and well-to-do Chinese, owing to the presence of this brigand soldiery, who crowd into every and any class of accommodation, and insult and rob without being checked in any way.

Lastly, the whole loan question should be considered and an international board established in Peking to apportion loans and supervise their expenditure. In addition, international representation on the Board of Communications, which controls the Chinese railways and telegraphs, should be insisted on, as only in this way will railway policy be efficiently and economically directed and each nation receive its fair share in the development of the existing lines. It is to be hoped that the above scheme will be found feasible, for the ill-effects of the Geman policy of relaxation of supervision of foreign loans have been only too well illustrated in the results of the policy of their Japanese imitators. This is one more instance of German conceit, which destroyed the labour their African colonies depended on for prosperity, ruined Turkey, and could learn nothing from us. If this scheme be found unworkable, then we must revert to the old system of spheres of influence, but it is to be hoped that the Foreign Office will not in future delegate its functions to cosmopolitan financiers and will see that there is some direction of finance which should have national aims. It is also to be hoped that this department will listen in future to its Peking representatives and will see to it that Great Britain is respected, for at present China shows a tendency to disregard her obligations to us and generally flout us.

Lastly, the creation of an international railway service is advocated on the lines of the existing Customs service, for at present every railway is independent and, therefore, there is no system in the matter of pay and prospects of the various foreign employees. At present this depends on what those in authority can wring out of the Chinese, and this is a question of personal popularity, skill and energy, which vary very greatly on the various lines, with the consequence that there is considerable unfairness which should be rectified.

In conclusion, China's most vital need is, so far as we are concerned, unlimited advertisement and the interest of powerful men with Cecil Rhodes ideas. To the bulk of people China is still merely the place where the tea comes from and where the people wear queues and live on potted dog and bird's nest soup, whereas the bulk of the 480 millions are hardly able to live at all, and exist in a state of misery and abysmal ignorance which it is part of our business to alleviate, apart from the consideration of the profit which is bound to accrue from the investment of British capital in China.

It would also seem to be a matter of public interest to know whether the management of the Hongkong Bank still lies in the hands of those directors who, to quote from Mr. Bland's book,* "so faithfully reflect German aims in China in outlining the Bank's policy in 1910." It is to be noted that Sir Carl Meyer, at any rate, was on the London Committee in 1916. An explanation or inquiry would appear to be desirable.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page 502.*)

THE meetings of this Institution were continued on Friday, the 11th inst., in the Hall of the Royal Society of Arts. At the morning session Sir William E. Smith was in the chair.

ELECTRIC WELDING IN WARSHIPS.

The first paper taken was one by Mr. W. H. Gard entitled "Some Experiences with Electric Welding in Warships." In the absence of Mr. Gard, owing to illness, the paper was read by Mr. S. V. Goodall. We intend to reprint this paper in an early issue.

Sir E. Tennyson d'Eyncourt opened the discussion. He regretted the absence of Mr. Gard, and particularly the cause of it, which was due to overwork. Mr. Gard had worked very hard during the whole war period, and had never allowed himself a holiday. His work had been invaluable and he much regretted to say that he was retiring shortly. The subject of the paper was one which Mr. Gard had made particularly his own, and his practical knowledge had ensured that in the work they had done they had run no undue risks. The system had been very valuable to them. For instance, in the case of the stern post of a battleship, which was dealt with in the paper, at the time the repair was necessary docking accommodation was very short, and to get a new stern frame cast and fitted would have taken many months. The period during which the dock was required was shortened enormously by the adoption of electric welding, but the decision to use it was a very serious one. They had to bear in mind the possibility of the welding failing when the ship was in action. Fortunately the results had justified the decision. He particularly desired to mention the good work of Mr. Cole, of the Quasi Arc Company, who carried out the job as sub-contractors to Messrs. Beardmore.

Cases in which electric welding had failed might be put down, he thought, to too much hurry, indifferent electrodes and lack of skill. The process required extreme care and lent itself to poor workmanship unless the workman has some incentive to good work. It was, however, very useful in many ways, and had been much used in America, notably in repairing the engines of German liners which had been deliberately damaged by the Germans. It would not do, however, to go in for the process wholesale. The difficulties of obtaining a good job in practice were too great. It was a very different thing carrying out welding in a shipyard from making little sample welds on a bench in a shop.

Mr. W. S. Abell noted that the paper, referring to welding for structural work, said "it will be necessary to train designers so to frame ship structures as to simplify the welding operation, to devise a practical means of detecting inferior welds, to increase the electric power available, to suitably protect both welders and workers in the vicinity and to increase the supplies of electrodes." All these matters were very important, and he associated himself in every way with what the author said. It would be of interest if he stated that Lloyd's approved the electric welding of a cracked cast-steel stern post in November, 1907. After service in May, 1908, it was examined, found slightly defective, and again repaired. Since then many such repairs had been carried out,

* The book referred to above is "Recent Events and Present Policies in China," by J. O. P. Bland (Heinemann, 1912) which fully disclosed the evil influence of our cosmopolitan finance in China.

with, on the whole, very few cases of failure. In connection with structural work it was important as far as possible to arrange for the downward welding which the author had spoken of. The welders should have the best conditions possible. In tests they had carried out they had not found welding to result in hot-shortness. The paper said the Admiralty did not regard the regulations for welding applied to structural work, which had been issued by Lloyd's, as at present applicable to warship work. He was not clear precisely what this meant, and would be glad if Mr. Gard could amplify it a little. In connection with the difficulties of erection and the closing of joints, he considered there were no intrinsic difficulties which could not be got over. He should have thought that the method would be applicable to small craft for the Navy. although possibly the light scantlings used might introduce difficulties not found in merchant work. Ultimately we would probably settle down to a combination of riveting and welding. The paper referred to failures of butt welds. Lloyd's had had the same experience, and did not now allow butt welds in main structures.

Sir George J. Carter said that the subject had been so ably dealt with by Mr. Gard, that there was little more to be said from the theoretical side. The method had been of very great value during the war for repair work. He might instance the case of a large stern tube casting which, in the ordinary way, would have been rejected owing to patches of spongy metal. This would have caused considerable delay. The tube, however, was welded up and made a satisfactory job, and now had been in service for a long time. The question of designing structural work, which was to be welded, in such a way as to suit the process was a very important matter. Much attention had been given to this point in the ship which Cammell Lairds were building. Overhead welding, which was the main difficulty, had been eliminated as much as possible. The process lent itself well to the carrying out of work in the shops, and large units were being assembled in this way, and afterwards built in. There were considerable delays in the yard, both frost and wet preventing welding from proceeding. The practical difficulties of applying welding work were not dealt with to any great extent in the paper. These difficulties were, however, of great importance, particularly those concerning the labour side of the matter. The welding plant was more or less expensive, and the electrodes were dear, and if one had to put two skilled men on each machine, and they refused to consider piece-work, and wanted 5*l.* a week each, no matter how much work they did, it was clear that the process had a good deal to contend with. There was no wish on the employers' part to reduce wages, but they did want a fair return for the wages paid. If electric welding was not going to be any assistance in the difficult labour conditions under which they found themselves, then it would not advance as its intrinsic value perhaps deserved.

Mr. J. Foster King, the next speaker, referred to a sentence in the paper which stated "it may be remarked that by comparing welded joints with riveted joints, the slip of a riveted joint under quite moderate stresses was shown up with considerable prominence." It was perfectly obvious that if you took pieces of plate, riveted them together, and put them under a tension test you would get slip, but this was not the condition which obtained in shipbuilding practice. The results of many years experience showed that the methods used for joining plates by means of rivets were perfectly sound. In practice there was no slip, the caulking did not give, and the riveted joint could be regarded as being equal in strength to the plate. In most actual cases of failure the plate gave before the rivets. Electric welding, or, as he preferred to call it, electric fusing—there was certainly no welding action—had proved its usefulness in many ways. Yet, however, there was room for further progress. In the case of a deck, for instance, if riveting was not used the plates would not be in contact, and strength depended on the material deposited. In cases of tension, also, the elasticity of the original plates and of the material deposited might be different, and one might get yield. He, however, was in sympathy with the view that the limits to the progress of science had not yet been reached, and there would yet be great developments, whether in the direction of pressure-welding or something else, he could not say. The direction of science at present was certainly towards the elimination of riveting.

Mr. O. A. Payne said, in reference to Mr. Abell's question about the Admiralty and Lloyd's regulations for welded structural work, that he believed Mr. Gard had in mind rather economic than engineering considerations when he said the Admiralty did not see their way to adopt these regulations. In connection with the welded stern post of a battleship, described in the paper, he would like to add a word or two, as he thought the small scale drawings reproduced hardly gave a good idea of the extent of the job. The main cutting away which had to be done left a trough in the post into which he could put his forearm. This, of course, had afterwards to be all welded up. Since the vessel had been in service only a very minor defect had developed in the post. It was necessary to be cautious about this class of work, however, and to make sure of a good job. Only a week ago a weld in the stern post of a 13,000-ton vessel had failed, and 8 lb. or 9 lb. of metal fell out of the weld. He believed in this case the welding had been done by gas. In connection with the welding work carried out by the Admiralty during the war, it was obviously best that most of it should be tried in connection with small ships, and obvious also that in the circumstances it would not have been an advantage to depart too far from standard methods of construction. In reference to Sir George Carter's remarks, he hoped for some reduction in the cost of the process, but was not too sanguine. Finally, he would say that in going about the country he had been struck by the small equipment which was available for electric welding, even in quite large yards.

Mr. McKay said that a good weld depended very largely on the comfort of the welder. His experience was that overhead welding could be carried out as satisfactorily as any other kind, but that a longer time was necessary. Good welders could be trained, and the efficiency of the job depended on the plant and materials as well as on the man. It was only by paying proper attention to the plant and materials that one got good work. In connection with cost he would like to say that his firm were bringing out a new plant which did better work than the old, and showed a saving of 50 per cent. in current. Thousands of jobs had been carried out satisfactorily under his supervision during the war. In one case a war vessel was sent home to have new boilers, the boilers, however, were repaired by electric welding, and she was sent back to the base in a few weeks. The preparation of the work before welding took place was an important part of the process. Electric welding was useful and would become more so, but he did not think the all-welded ship would come quickly. What was greatly desired now was a method of distinguishing a good weld from a bad.

Mr. C. E. Stromeyer said he firmly believed electric welding could be done to produce thoroughly efficient joints, of consistent quality. In Mr. Abell's tests of electric welds he obtained a strength of about two-thirds that of the material jointed, while the results were consistent and lay on a straight line. In this they compared very favourably with tests of ordinary welds. Mr. Stanton's test results for such welds, for instance, were scattered all over the diagram, and showed no consistency. Failures with electric welding were due to the workman and not to the process.

Mr. Goodall, concluding the discussion, said that he would leave the various points which had been raised to be dealt with by Mr. Gard in writing. He would like, however, to take the opportunity of saying what great assistance Mr. Gard had rendered him in connection with this subject while he had been in America. It was a subject on which co-operation between the Admiralty and the United States Navy authorities had been very close.

STRESSES IN FLAT STEEL PLATES.

The next paper to be dealt with was one entitled "Further Experiments on the Stress Determination in Flat Steel Plates," by Dr. J. Montgomerie. In the absence of Dr. Montgomerie, it was read in abstract by Mr. W. S. Abell. The paper formed a continuation and extension of that read before the Institution by Dr. Montgomerie in 1917.* It described experiments for determining the stress and strain in flat plates of mild steel, supported at the edges and exposed to uniform hydraulic pressure over the unsupported surface. The general conclusions of the paper—which we intend to print in a future issue—were :

1. That the stress in plating due to water pressure is not so great as has been assumed, and under the same conditions of loading is not of the same order of magnitude as the stress developed in the stiffeners.

2. That, accordingly, the plating of watertight bulkheads in cargo steamers, oiltight bulkheads, deep tanks for water ballast and all parts of structure intended primarily to resist stresses due to water pressure, could, from the strength point of view, with safety be of reduced thickness in relation to that at present fitted, the stiffeners being of efficient design.

3. That the increase in the thickness of the shell plating of steam vessels in respect of wider frame spacing, as fixed in the Report of the Committee appointed by the Board of Trade to advise on the load lines of merchant ships provides for substantially the same stress conditions in the new conditions as in the standard vessel.

Mr. Abell, after summarising the paper, said he would like to congratulate the author on the amount of work he had done, and on the able way he had condensed his results. Dr. Montgomerie had a genuis for reducing the results of a large amount of complicated work to a simple form. The simple formula given connecting the stresses in a plate with the thickness would be of great use. The formula of the Freeboard Committee had been determined empirically as a result of trial and error, and certainly in a sense on insufficient evidence. It was gratifying to know that Dr. Montgomerie had found this formula to be correct for all practical purposes. In connection with the results which followed from the paper that wider frame spacing might be allowed, there was a possibility that if this were done, new conditions might arise in the plating owing to secondary flexure. The matter required still further investigation. He could hardly, however, ask Dr. Montgomerie to investigate this in view of the amount of work he had already done. The demonstration that in the case of watertight bulkheads we might reduce the thickness of the plating if the stiffeners were all right, was confirmation of an idea in the direction of which his thoughts had long been tending.

Mr. L. Woolard said the paper formed a contribution towards the solution of a problem which had troubled naval architects for years. It had been shown long ago that on existing theory a $\frac{5}{8}$-in. plate in a battleship bulkhead was not strong enough to support the water pressure which it actually did support. Dr. Montgomerie's work threw further light on the matter. In the comparison of his new formula with Grashof's formula, had the author considered taking Grashof's formula for an infinitely long plate and modifying his own formula to correspond. This could be done by taking the length from one corner to a line joining the two adjacent corners instead of the breadth. If this was done it would be seen that the results of theory and practice approached one another very closely. Dr. Montgomerie had showed that you could not consider plates as fixed at the edges, but he hardly thought this was true for a continuous plate with reinforcement. The experiments did not exactly compare with the case of plates on a ship's side.

Mr. J. Duncan said that the whole of the experimental work on which the paper was founded had been carried out in the laboratory of the West Ham Technical Institute. Dr. Montgomerie had put in an enormous amount of work there, and he had assisted him. In using the results of the

* See ENGINEERING, vol. civ, page 35, *et seq.*

investigation, it had to be remembered that it was only concerned with plates having a ratio of length to breadth of 2 to 1, held rigidly at the edges. Work was now required on plates of other form—square, with length to breadth—2 to 1½ and so on. The simple formula established in the paper $f = \frac{0{\cdot}067\ p}{t^2}$ applied only to those plates with the 2 to 1 ratio. For other ratios the numerical coefficient would probably be different. The plates which had been cold-rolled were tested just as they were received from the makers. The frame in which the plates were held was so stiff that there was no bodily movement of it. This was proved by having a mirror mounted on it, and using a beam of light. There was, however, elastic straining, as pointed out in the paper. A point arose in connection with the jointing material used between the plate and the frame. This would modify the elastic strain of the frame. The effect could only be measured experimentally, and would probably be best dealt with by measuring the slope. It was hoped it would be possible to carry on further research at West Ham.

Mr. J. Foster-King thanked Dr. Montgomerie for a practical contribution to science. The work had been carried out on a definite plan, and had led to a definite conclusion. He thought the effect of the constraint of the plate disappeared within one-third of its length, and that the formula was a definite contribution to practice.

In the absence of Dr. Montgomerie, this concluded the discussion of the paper.

The Tonnage of Steamships.

The next paper was one by Mr. A. T. Wall, entitled "The Tonnage of Modern Steamships." It was read in abstract by the author. The paper compared the effect of the different methods of computing tonnage in use throughout the world, and the effect of the rule for deduction of tonnage from propelling space as it bore on recent advances in propelling machinery. A case was quoted in which a reduction in the space of the propelling machinery, by the adoption of geared turbines or oil engines, would actually result in a loss of revenue of 4,000*l.* a year owing to the incidence of the tonnage rule. We reprint this paper on page 549.

Mr. S. B. Freeman said he had had no opportunity of studying the paper, but thought it appeared very important from the present point of view of reconstruction. Owing to war conditions, a large number of ships had carried oil in their double bottoms, and shipowners had obtained confidence in the method. If the practice was extended, and oil was so carried for fuel with a resultant increase in cargo space, it seemed remarkable that a shipowner was going to be penalised for merely doing his duty and carrying as much cargo as possible.

Mr. P. A. Hillhouse congratulated the author on the paper, which must have involved an enormous amount of work. The computation of tonnage by means of displacement was very simple, and it would be a boon if one could work in terms merely of length, breadth and depth. The net displacement bore a fairly constant relation to block displacement. In connection with the annual loss of 4,000*l.*, he would like to ask if this took into account the possible economies of the newer plant, and the increased return from cargo carrying. If it was an overhead result, the present tonnage ruling was a very serious bar to progress.

Mr. A. T. Wall, in reply, said he thought the subject of the paper was one that would become of great importance. In connection with Mr. Freeman's remarks on the carrying of oil fuel, he would say that at the moment it was not possible to measure the gross tonnage, including the double bottom, even if oil fuel was being so carried. This was merely another example of the necessity for overhauling the tonnage rules. The case of the 4,000*l.* he had quoted did not take account of possible economies due to the new plant. These the shipowner had the right to get the advantage of, owing to his expenditure in making the change. The figure of the loss was that due to the plain tonnage measurement and was quite unjustifiable.

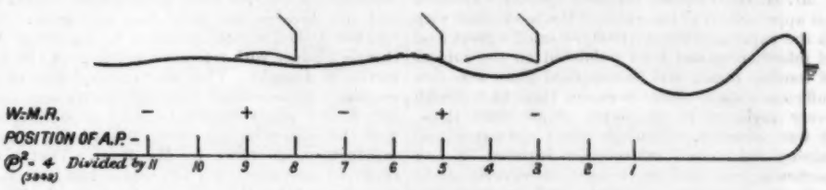
This concluded the discussion of the paper, and the meeting then adjourned until the afternoon.

Model Experiments on the Effect of Beam, and Experiments on Full Cargo Ship Models.

In the afternoon the closing meeting of the session was held, and it was devoted to the reading and discussion of two papers giving the results of experiments on ship models. The chairman, Sir William E. Smith, said the papers contained much valuable matter in little space and, as the subject-matters of both were similar, he thought they might well be discussed together. The first paper read was that by Mr. J. L. Kent, entitled "Model Experiments on the Effect of Beam on the Resistance of Mercantile Ship Forms," and the results given in it form the concluding portion of a programme of research, carried out at the William Froude National Tank, upon the effect of certain changes in form and dimensions on the resistance of an ordinary mercantile steamer. The second paper, entitled "Some Experiments on Full Cargo Ship Models," was by Mr. James Semple, of Clydebank, and it contained the results of experiments made to determine the effect of fullness, and of longitudinal distribution of displacement, on the performance of ships of average proportions. Wake and thrust-deduction investigations were also carried out on a number of the models used, and, in addition, some comparisons are drawn between the results obtained at Clydebank and in other establishments. We reprint Mr. Kent's paper on page 550 and shall give Mr. Semple's in an early issue.

Mr. W. J. Luke, who opened the discussion, said that he was now rather out of touch with the matters dealt with in the papers, but he was glad to be able to congratulate the authors on their very excellent productions. He noted, with interest, that the whole series of experiments, the concluding portion of which were referred to in Mr. Kent's paper, had involved the making of no less than 5,500 runs, and he thought this was sufficient evidence to justify the acceptance of the general results reported. Mr. Semple's paper, however, was not less valuable on this account, as further matter of the same sort was well worth publishing. He hoped it would be found that all the results given would corroborate each other sufficiently to be satisfactory for use; but this was not always the case. There was, he said, considerable difficulty in reconciling the results of the propeller experiments given in Taylor's paper in 1904 before the American Society of Naval Architects and in Taylor's book, with the Haslar experiments. He hoped that many of the model experiments would harmonise better. He mentioned some German experiments comparing the effect of bossing with "V" shaft brackets, in which over 200 runs were made before the experimenters accepted their own results. He was not *au fait* with the conditions affecting the resistance of cargo ships, and had thought it quite a simple matter to estimate the power required for a 10-knot tramp. He found, however, that it was possible to get variations of the order of 80 per cent., and was glad he had not fallen into such an error. Designers of tramp steamers should be very grateful to the authors of the paper for helping them to improve efficiency. The papers would lead to improved economy in running, as others did to economy in construction. In Mr. Semple's paper reference was made to differences between his results for wake and thrust-deduction values, and hull efficiency, and those of Commander McEntee. In such a case it was always desirable to endeavour to trace out the cause, as Mr. Semple had done. Such results should never be accepted blindly. It was best to analyse the results of reliable trials with the screw propeller results available, and come to one's own conclusions as to wake and thrust deduction values.

Mr. P. A. Hillhouse, the next speaker, said that, in the old days of ship design, the form was settled by instinct, or whim, but since then a mass of experimental data had been published to assist naval architects in designing ship forms. In spite of this it never seemed possible to find data for the exact requirements of any particular case, and usually one had to interpolate one set of results with another. He wished to refer to the series of humps and hollows found in the curves of (C). In trials on the measured mile these humps and hollows were not found, and the explanation given was that the ships were not tried at a sufficient number of speeds. Usually only three spots were taken, and even when five were taken the occurrence of a spot in a high or low position was usually attributed to experimental error. Mr. Baker had rendered a great service in showing where to expect humps and hollows, and enabling a decision to be made as to whether any particular point obtained was an error or not. In studying Baker's work in connection with (P) values he had experienced difficulty in co-ordinating the value of (P) with the humps and hollows it represented. He had, however, drawn a diagram (reproduced herewith), which he thought



would help to elucidate the matter, and he would like to know if this were correct. The diagram showed the bow-wave profile, for one particular speed, along the side of the ship, and showed different positions of the stern-post relatively to the waves. The signs showed the points at which the bow and stern wave systems add or substract, giving rise to humps and hollows in the (C) curves. If the diagram were correct it showed whether maximum, minimum or average results would be obtained for any particular value of $(P)^2$. He asked what happened when $(P)^2 = 2\frac{1}{4}$. At this point there was an abnormal hump, but this did not come in the diagram. In designing a boat, if $(P)^2$ did not come right, (P) could be altered either by reducing the prismatic coefficient, or increasing it, and he asked it it would be advisable deliberately to increase the prismatic coefficient for this purpose.

Sir J. Biles, who followed, said he feared he could add nothing of value to the discussion. The real value of papers of this nature could be obtained only with the assistance of the younger men. With regard to Mr. Hillhouse's statement that humps and hollows did not occur in horse-power curves, he had given attention to this matter as long ago as 1883. In the early days a method of finding the speed of ships off the measured mile, known as the Dutchman's log,* was employed. With this arrangement the speed could be varied so as to get the spots to come close together, and humps and hollows were found in one case, which had been recorded in the Transactions. If speeds were taken close together he thought the humps and hollows would be found with full-size ships as they were with models. Now that there were so many tanks in existence he wondered whether the zero was the same for all of them, and he thought they should compare notes to see whether or not this was the case. At one time there had been a dispute as to the relative value of ships with straight and hollow water lines, but the dispute eventually turned upon the question of the accuracy of two sets of model experiments. We were now in a position to rely on tank results, and the more they were published the better chance there would be of getting to a common zero. Tank

* See page 365 *ante*.

experiments now covered the whole range of investigations of ship form. At one time they had been mostly concerned with fine forms and high speeds, but they now had to consider the effect of variations in fuller forms. From his experience, Sir John mentioned the case of a ship required for a special purpose. Its duties were such that it had rarely to move, being generally used at rest. On looking up model experiments it was found that a form with a block coefficient of 0·85 could be propelled almost as easily as one with a coefficient of 0·75, and it was therefore decided to adopt the fuller form. This, he thought, was a good example of the practical value of tank experiments. He also wished to acknowledge the value of the William Froude tank, at the National Physical Laboratory, to those who had not a tank under their own control. As an instance of this he mentioned a case in which Mr. Baker, investigating an uncommon form, had been able to improve it so that a reduction of 30 per cent. in the horse-power required had been obtained.

Mr. W. H. Whiting, on being invited by the chairman to contribute to the discussion his views as to the relative value of forms with straight or hollow lines, said he regretted that he had no special information on this point. The Admiralty had not instituted actual trials between the two types of vessels.

Mr. H. G. Williams, the next speaker, expressed his appreciation of the value of the work dealt with in the papers. Prior to 1909, he said, a great deal of information had been published on the subject of warship forms, and he supposed there were now sufficient data available to enable them to deal with every variation in the forms of merchant ships. It was, however, difficult to select the paper containing the actual information required in any particular case, and he thought the experts might well do something to collate and condense the published information into some more accessible form. At present the results were given by different investigators in different forms, and a great deal of slide-rule work was necessary to enable the results to be compared. The most valuable feature of Mr. Semple's paper, he thought, was the hull efficiency experiments, the information on this matter being much more meagre than that on tow-rope resistance, although the former was equally necessary for practical purposes. It was always a difficulty with wake and thrust-deduction values to find the governing variable with which the variations could be connected. Empirical formulæ had been proposed, but none was really satisfactory. Mr. Semple's paper showed a large variation of wake and thrust deduction values with the prismatic coefficient of the after body. An increase of resistance was also experienced with increase of prismatic coefficient of the after body, and this seemed to him to be the fundamental law on which wake and hull efficiency ought to depend. One might get a simple law of wake by comparing results on (C) values. Wake depended on many features, and really depended on the resistance of the ship itself.

Mr. A. T. Wall, who spoke next, said he fully endorsed Mr. Williams' remarks with regard to the forms in which the results of model experiments were presented, and he thought that if all were collected and put on a common basis it would be very valuable. His view was that the more information obtained as to forms, the more accurately the lines could be produced for a given ship. He had produced a set of lines for a fine Channel steamer which could not be improved in the tank, and, if this could be done for a fine-form vessel, it should be more easy to do it for a merchant ship. Of the three methods of beam variation dealt with in Mr. Kent's paper, he thought the first, in which the beam was varied while the length and draught remained the same, was the most useful, and the third case was not likely to occur in practice. In Mr. Semple's paper it was stated that it was an advantage for the centre of buoyancy to have a forward position, and this was a good thing from a sea-going point of view. The speaker also thought it would be interesting to take a series of ships, estimate the deadweight of each, and find out how the horse-power varied with the deadweight. In Mr. Semple's paper he noticed the statement that the resistance of a 400-ft. ship would be increased by 80 per cent. by bringing the centre of buoyancy back from 2 per cent. forward of amidships to 2 per cent. aft of amidships. This was, he thought, a very astonishing statement, as with such a ship three-quarters of the resistance must be skin. The wave-making resistance of the ship with the centre of buoyancy astern would, therefore, have to be multiplied by four.

The last speaker was Mr. G. S. Baker, who said that with regard to the agreement of the zeros of different tanks, they had, before commencing commercial work in the William Froude tank, run comparative models with all English tanks, and also with those at Clydebank and Washington, and had found the results always in agreement to within 1 per cent. or 1½ per cent. There was a little difference at very high model speeds, but this was not thought to be of much importance. Since then another model had been run against a tank in the United States under different conditions, and a good agreement had been obtained in the results. Two years ago they had run a model against the Dumbarton tank and obtained a satisfactory agreement. The National Physical Laboratory had also found results similar to those of Mr. Semple, so that he thought nothing further was needed in the matter. He was of the opinion that many of the apparent discrepancies were due to the fact that comparisons were not made under proper conditions, and not because the data were inaccurate. The speaker wished to call attention to a point in Mr. Semple's paper with reference to the good effect of increased draught. This was an easy way of increasing displacement without increasing skin. Mr. Kent's paper should be read in conjunction with this statement, increasing beam being equally satisfactory, as shown by Mr. Kent. That beam could be increased with advantage had now been corroborated by the example from Sir J. Biles's practice. With regard to the straight-frame ship model experimented on by Mr. Semple, the speaker noticed that the run of the chine line was not shown. This was an all important factor, as results differing by as much as 60 per cent., on account of the position of the chine line, had been obtained. He therefore thought it essential that this item should be furnished. On the subject of wake and thrust-deduction values, he noticed that McEntee gave big wake values with full after ends. Experimenters were, however, liable to fall into errors in wake values. The whole of these values should not be included in hull efficiency. Doubtless a way would be found of dealing with hull efficiency for full line boats. With regard to the series of experiments the conclusion of which was dealt with in Mr. Kent's paper, they had found the results of considerable value to them in their own practical work, and he, therefore, thought it likely that the experiments would be valuable to others. Other methods of presenting results could, of course, have been used, but Mr. Semple had stated that he would have given his in the same form as they had if he had started in the same way. The speaker did not think there was any great difficulty in going to the papers published to get data.

The Chairman, in calling on the authors to reply to the discussion, had to request them to be very brief owing to the lateness of the hour. Mr. Kent, who replied first, said he had been greatly surprised by the length of the discussion. His paper was a compilation of data intended to be of use to naval architects when changing beam. He had shown three ways in which this might be done, and papers by Rota and Scribanti had shown other ways. One speaker thought the methods dealt with in his paper unpractical, but Rota appeared to think differently. With regard to Mr. Hillhouse's remarks on the question of humps and hollows, he would have to consider the diagram more fully before dealing with them. The position of the sternpost was, however, not correctly given for the (P) values shown. Interference must take place along the run and not aft of it. He would, however, send a fuller reply in writing for publication in the Transactions.

Mr. Semple said his thanks were due to Mr. Luke for permission to present the results given in his paper. With regard to Mr. Wall's criticism of the increased resistance due to movement of the centre of buoyancy, he had no reason to doubt the results obtained, but he thought they must have had a very bad form. Mr. Baker, in his Glasgow paper, had given a splendid form in which the centre of buoyancy was well forward of amidships, but when the centre of buoyancy was placed aft eddymaking was enormously increased. Wave-making and eddy-making, he thought, amounted to about 20 per cent., but it was not safe to say. In any case, the results showed the necessity for steering clear of assumptions. He would also send a written reply.

The meeting then passed a vote of thanks to the authors for their papers, after which a vote of thanks to the Council of the Royal Society of Arts for the use of their lecture hall was proposed by Mr. W. H. Whiting, seconded by Mr. H. R. Champness, and carried. Votes of thanks to the gentlemen who had presided at the various meetings of the session, and to the secretary and staff of the Institution, were also passed, and the meeting then terminated.

CONDUCTIVITY OF POROUS MATERIALS AT HIGH TEMPERATURE.

AT the meeting of the Ceramic Society, at Stoke-on-Trent, on April 14, a communication by Dr. J. W. Mellor, entitled "The Heat Conductivity of Porous Materials and the Heat Insulation of Kilns," was stated to be introductory to a later paper by Messrs. Edwards and Rigby on "Conductivity of Firebricks," the experimental work for which had not been completed at present.

In 1914, Dr. Mellor raised the question of the effects of heat on porous materials, and expressed the unorthodox view that at high temperatures they might become conductors instead of insulators. Under ordinary conditions, the quantity of heat passing along by conduction is much greater than the quantity radiated across the air spaces. Dr. Mellor made a calculation which indicated that with pore spaces 0·1 cm. across, these two quantities of heat would be equal at 1,400 deg.C. The same would be the case at a higher temperature when the pores were smaller, or at a lower temperature with larger pores. Thus, with pores 0·01 cm. across the temperature would be about 3,000 deg. C., and with pores 0·5 cm. across the temperature would be only about 730 deg. C., the insulating properties beginning to break down at higher temperatures. In these calculations no allowance is made for conductivity of air, or for any change of conductivity with rise of temperature, and convection by currents of air is also neglected.

The actual temperature of the breaking down of insulating properties is apparently well within the range of ordinary kiln temperatures, as pores of 0·01 cm. across would hardly characterise highly porous materials.

In order to examine the point experimentally, bricks of various degrees of porosity, &c., were made with three cavities penetrating longitudinally to different distances into the bricks. In these cavities thermocouples were inserted to enable the temperatures at different points of the bricks to be ascertained. The results will be published after the experiments are completed.

GERMAN INDUSTRY.—Owing to the precipitate demobilisation, the German machine industry is in a precarious state, says the *Deutsche Allgemeine Zeitung*. Factories working at the highest pressure on army contracts have been compelled to change to a peace footing without respite. Although the cancellation of important military contracts freed considerable quantities of iron and steel for peace requirements, instead of the anticipated rush of work, unemployment is prevalent everywhere. The principal causes for the dearth of important peace orders are: (1) The shortage of raw materials (as in the textile trade). This, together with the coal shortage, not only prevents the closed down factories from re-opening, but provides no incentive for the acquisition of new machinery. (2) The mining, iron, and electric works, threatened with socialisation, show a natural reluctance to place orders. (3) Other industries are awaiting a general fall in prices or are covering their needs from old Army stock. (4) Special machines and iron constructions (bridges, halls, &c.) cannot be put in hand without the completion of computations and drawings by technical experts. At present, therefore, the home demand is confined to locomotives, railway carriages, ships, and agricultural implements and machines. The locomotive and truck factories have been working for weeks to fulfil the severe Armistice conditions relative to the delivery of rolling stock, and hence are unable to satisfy the urgent home demands. Furthermore, the home market, deprived of East and West Germany, is now too small to provide sufficient work for the greatly enlarged machine factories. The foreign market, which in peace time absorbed on an average 25 per cent., in some cases 50 per cent. and more, of German machinery, cannot be reckoned on as an important factor in the near future. Through the embargo on the export of machinery the export trade, which in 1913 averaged 596,000 tons to the value of 681,000,000 marks, declined in 1918 to about 90,000 tons to the value of 224,000,000 marks. (Judging by the weight figures, the decline is actually much greater, owing to increased cost of production.) Although the export restrictions have been greatly mitigated, it is very doubtful whether, with the present price of raw materials and the high wages asked, Germany will be in a position to compete on the neutral markets.

LIGHT WEIGHT ELECTRIC GENERATING SETS.

CONSTRUCTED BY MESSRS. A. LYON AND WRENCH, LIMITED, WILLESDEN, LONDON.

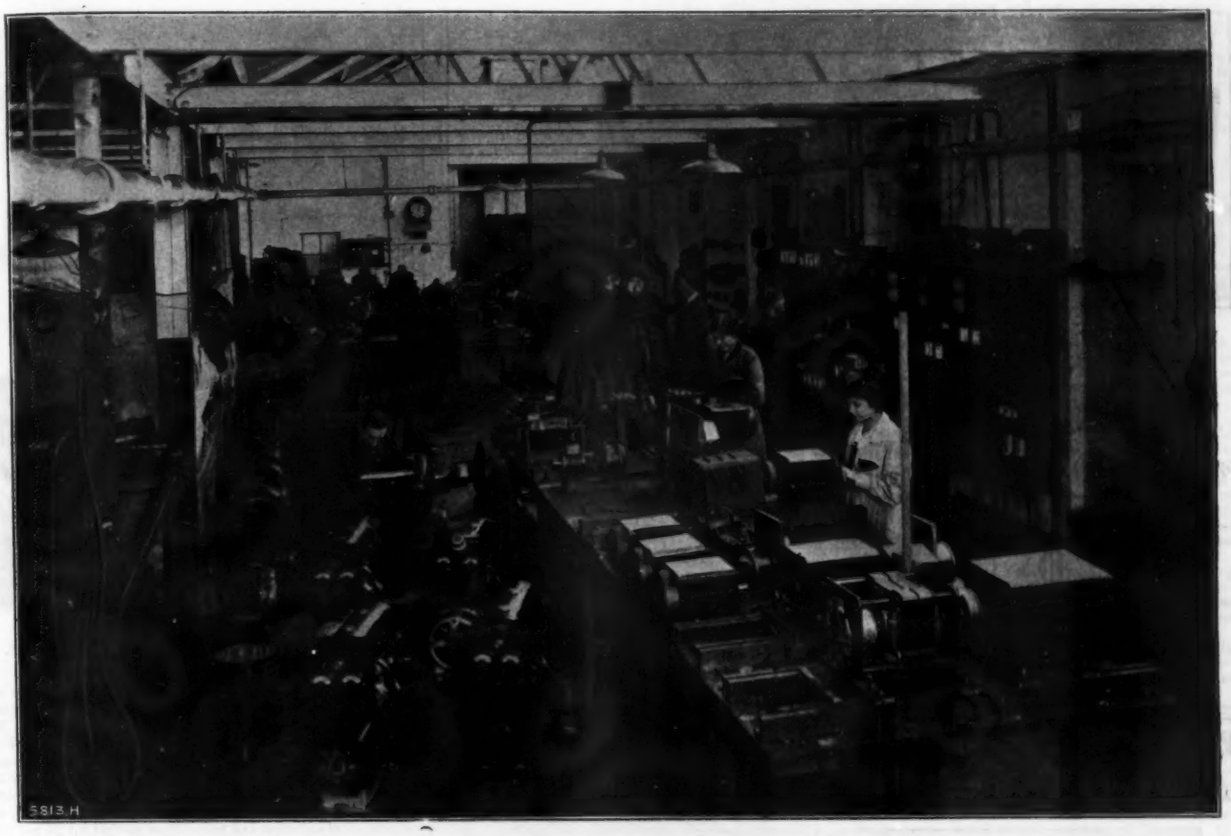
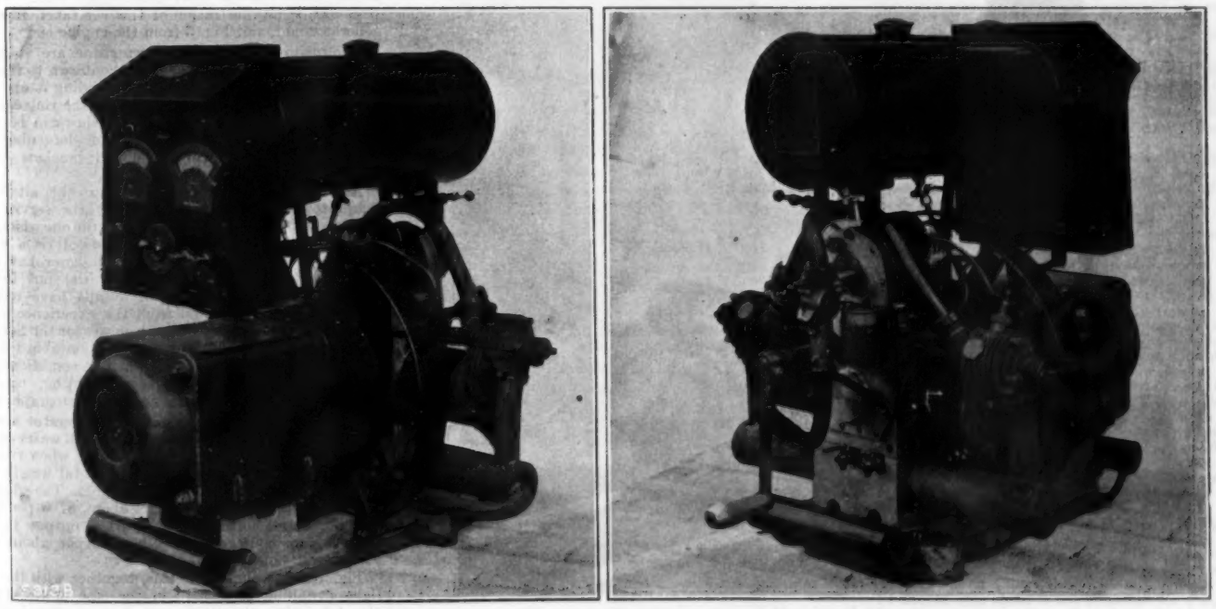


Fig. 1. View of Test Bay.



Figs. 2 and 3; 2-Kw. Sets.

On the present page and page 532, we illustrate a combined set consisting of a generator manufactured by Messrs. A. Lyon and Wrench, Limited, of Willesden, direct-coupled to an A.B.C. petrol engine. The set is typical of the special light-weight air-cooled sets which this firm have supplied to the Admiralty, the War Office and the Air Ministry for regular service in connection with the war. Amongst the purposes for which they have been used may be mentioned the supply of power for daylight signalling, X-ray apparatus, battery charging, landing lights for aerodromes, and general lighting of huts, dug-outs, &c. Due to their light weight and compactness, they were also used upon many services where they had to stand rough usage and be ready for continuous runs for long periods under trying conditions; in fact, they were run right up at the front line.

The firm realised, upon undertaking the work, that

LIGHT WEIGHT ELECTRIC GENERATING SETS.

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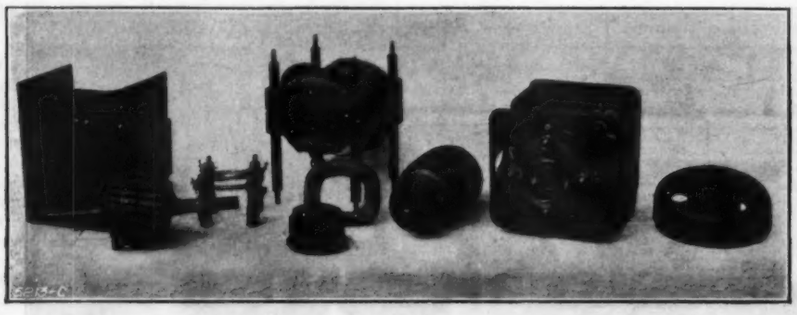
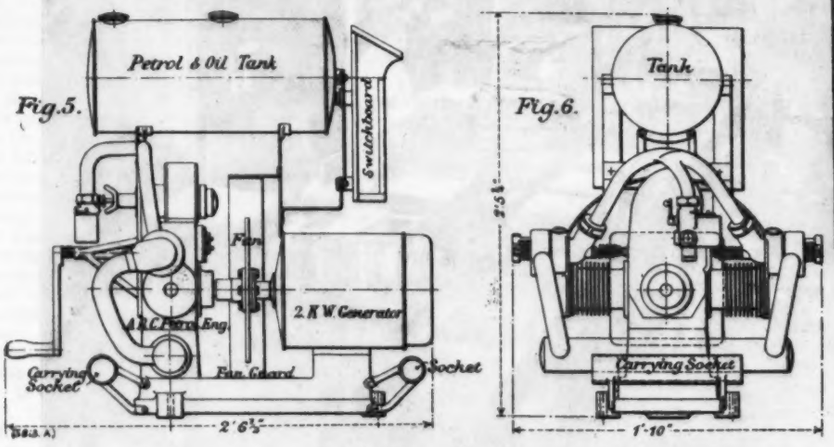


FIG. 4. 2-KW. GENERATOR, DISMANTLED.



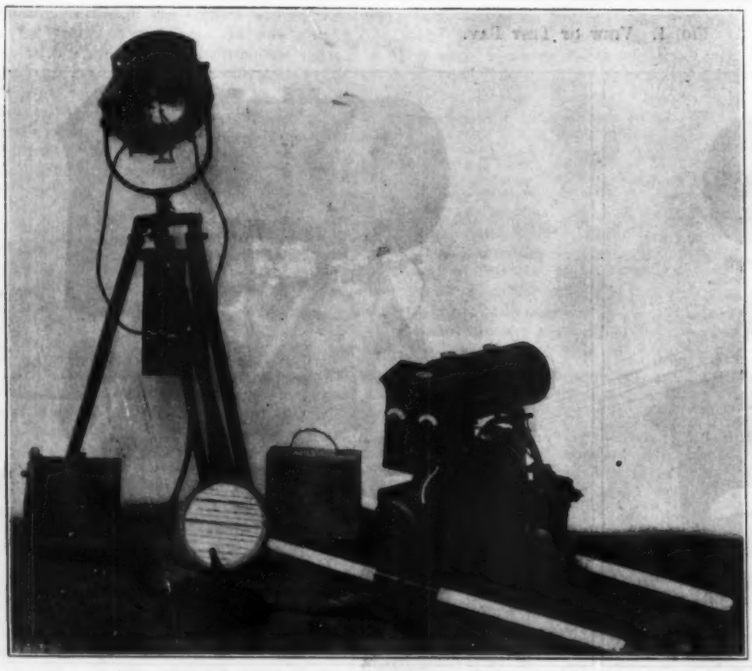


FIG. 7. DAYLIGHT SIGNALLING PROJECTOR, ADMIRALTY PATTERN, WITH L. AND W. GENERATOR.

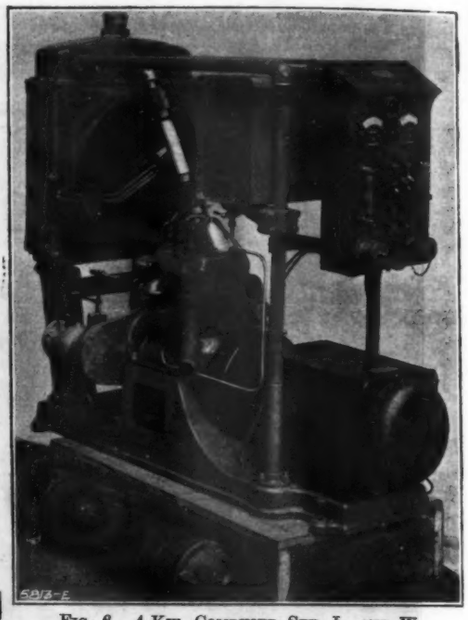


FIG. 6. 4-KW. COMBINED SET, L. AND W. GENERATOR AND COVENTRY SIMPLEX ENGINE.

it was necessary to limit, from a manufacturing point of view, the number of sizes, and, therefore, the outputs; they have, at the present time, fully standardised designs for direct-current generators from 1 kw. to 6 kw., and a line of motors giving from ½ h.p. to 6 h.p. on either a 110 or 220-volt circuit.

The standard machines are made in three main types, namely, the protected, the enclosed ventilated and the drip-proof, and the construction of all is such that they comply with the rules of the British Engineering Standards Committee. They are manufactured and passed through the shops on a system in which limit gauges, inspection and testing, play an important part.

The interesting feature of the machine is the neat design of the generator, which has in a great measure made it possible for the firm to produce such a light and portable set. The combined set shown in Fig. 5 has an output of 2 kw., and the overall dimensions are only 2 ft. 6½ in. long by 1 ft. 10 in. wide by 2 ft. 5½ in. high; the weight inclusive of the switchboard is 175 lbs. The output is 10 amperes at 200 volts, with an overload capacity for a short period, of 25 per cent., at a speed of 2,500 r.p.m. The efficiency of the generator is about 82 per cent., with a petrol consumption at full load of about 0·44 gallons per hour. Fig. 2, page 531, is an illustration of this set taken from the generator end, and Fig. 3 from the engine end.

The main details of the generator are shown in Fig. 4, and special attention may be drawn to the type of field frame and the method of building it up. The brush gear is also interesting, in that the ring carrying the brush arms and the carbon brushes can be withdrawn bodily from the frame after loosening four screws, without disturbing the end brackets or the bearings.

Any of the types of machine can be altered in detail to meet the requirements of the service, but the firm's "Commercial" machine is the one which they intend to manufacture in quantities. It is a robust machine for its weight, and the designer has made full use of the weight of all material put into it. The electrical and mechanical details have received careful consideration, and from the experience gained in turning out the large number of sets for the Services, there is no doubt but that they are suitable for continuous running under normal working conditions, and should prove useful for private lighting, charging batteries, X-ray apparatus, and cinematograph work.

Fig. 6 shows the 4-kw. standard generator coupled direct to a Coventry Simplex engine, with water cooling The output is 20 amperes at 200 volts, when running at a speed of 1,400 r.p.m., and the total weight with the radiator and switchboard is 672 lbs. The efficiency of the generator at full load is about 87·5 per cent., and the petrol consumption at 4-kw. output is 0·60 gallons per hour, and at 2-kw. output about 0·46 gallons per hour.

Fig. 7 shows one of the sets, together with the daylight signalling projector; in the case of the sets for the Admiralty, the 10-in. projector was fitted with a special shutter. The weight of the set, inclusive of the switchboard, is 165 lbs., the nominal output, 25 amperes at 70 volts, but the set is suitable for running continuously at 31 amperes 65 volts; the speed of the set is 2,500 r.p.m. The efficiency is about 81·5 per cent., and the petrol consumption, when giving an output of 2 kw., is about 0·44 gallons per hour.

Fig. 8 shows the battery charging set, and in Fig. 9

LIGHT WEIGHT ELECTRIC GENERATING SETS.

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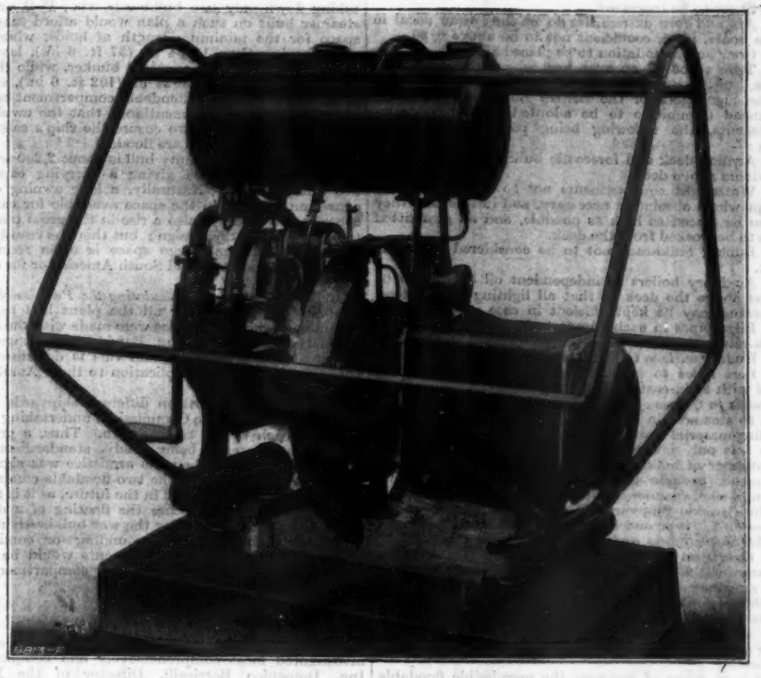


FIG. 8. L. AND W. BATTERY CHARGING SET.

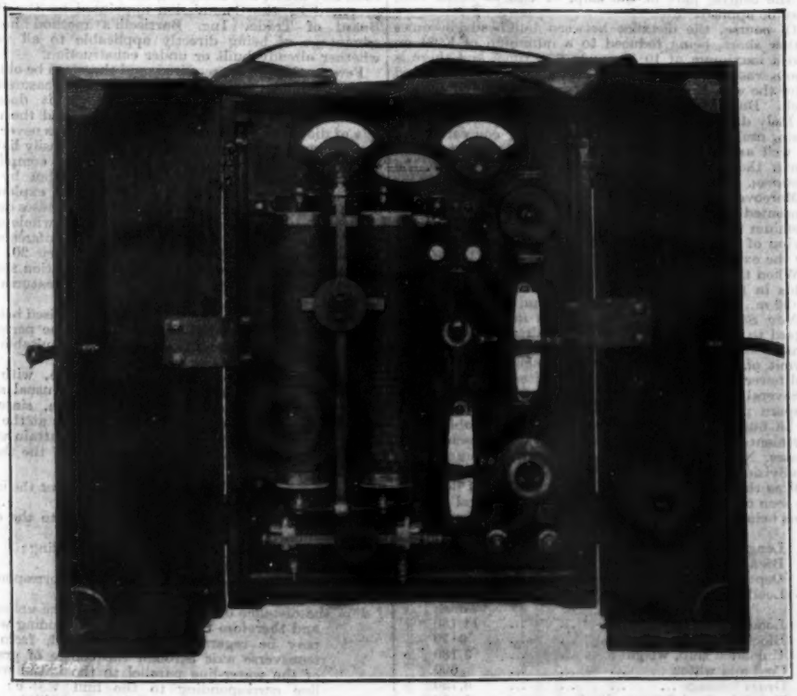


FIG. 9. PORTABLE SWITCHBOARD FOR L. AND W. BATTERY CHARGING SET.

is shown the separate portable switchboard. The output of the charging set is 1 kw.—20 amperes at 50 volts when running at 1,800 r.p.m. The weight of the generator and engine complete is 152 lbs. The generator efficiency is about 78 per cent., and the petrol consumption when running at full load is about 0·26 gallons per hour. The rails fixed round the set are for supporting a waterproofed canvas protecting cover used by the service at the Front.

It will be seen from the particulars already given that the firm have had considerable experience in the manufacture of these small sets for specific work. Some idea of the quantities passing through the shops towards the end of last year, may be gathered from an examination of Fig. 1. This is a view of the test-bed at the works at Willesden, N.W., where about 500 employees are at work. The firm is a combination of the Arthur Lyon Company and the John Wrench Manufacturing Company. The latter firm have been established over 100 years, and are specialists in the manufacture of cinema apparatus, which is now being made at the works at Willesden, N.W.

ITALIAN TWO-FLOODABLE COMPARTMENT CARGO STEAMERS.*

By ING. SALVATORE ORLANDO, Honorary Member.

ABOUT the middle of 1917 the losses of the Italian mercantile marine had risen to such an extent that it became evident steps would have to be taken to prevent the total destruction of the whole fleet.

Despite the fact that all these ships had been armed under the direction of our naval authorities, and that navigation rules had been put into force in accordance with the decisions of the Allied Committees, public opinion as expressed by articles in the technical and political newspapers pointed out the necessity of adopting means to render the steamers safer from torpedo attacks. Several systems were suggested by naval engineers and others connected with private firms whose proposals were thoroughly discussed.

This general movement resulted in a meeting being held in Genoa on August 18, 1917, attended by almost all the leading engineers of Italian private shipyards and several naval authorities.

At this meeting the question of the means to be adopted for the preservation both of the ships still existing and of those to be built was examined and discussed, the outcome being the passing of the following resolution :—

"Engineers and technical men assembled in Genoa on August 18, 1917, in order to examine from a technical standpoint the urgent national question of the reconstruction of the mercantile fleet and the conservation of the remaining vessels, having considered the various systems proposed to prevent the total loss of existing steamers by the introduction of light materials in the holds at the extremities and by other means, and also those devised for obtaining the same results in new ships by adopting longitudinal compartments or by alterations in the hull design, while they welcome such proposals for the purpose of safety, are of opinion that for the new cargo boats their post-war mercantile carrying capacity must primarily be taken into consideration.

"They consider, therefore, that the keeping afloat of the new ships after a torpedo explosion may be secured by adopting such transverse watertight subdivision as is capable of rendering the vessels safe with at least two compartments flooded, without altering the general design of hull which has been proved by long experience to be suitable for mercantile purposes, and they request that a committee consisting of a few experienced engineers be appointed to examine and draw up rules for the aforesaid subdivision, and to report on the matter as soon as possible."

This resolution, which was placed before the Minister of Transport, Signor Bianchi, led to a Decree dated September 10, 1917, in which the committee in question was charged with the duty of studying proposals with the object of—

"Assuring the floating of cargo boats by means of transverse subdivision capable of keeping the ships afloat with two compartments flooded, without altering the usual general design of the hull, as commonly accepted."

The committee presided over by myself was composed of Signor Domenico Barricelli, Director of the National Registration Society; Professor Alberto Beneduce, chairman of the National Insurance Institute; Signor Boselli, manager of the Fiat San Giorgio Shipyards; Ing. Enrico Matteo, of the Odero Shipyards; Ing. Luigi Orlando, of the Fratelli Orlando and Co. Shipyards; Ing. Piaggio Rocco, manager of the "Cantieri Riuniti"; Ing. Nabor Soliani, manager of the Ansaldo Shipyards; and Ing. Valsecchi, R.I.N.R.

This committee set to work immediately, taking into careful consideration what had already been done by the International Conference on the Safety of Life at Sea, and by the Bulkhead Committee presided over by Sir Archibald Denny in England.

Several meetings took place, the time between each being devoted to studies and calculations of stability in non-contact conditions. In the short space of about three months the committee was able to bring its work to a conclusion, and this was greatly facilitated by what had already been done and published.

The committee's researches were confined to two sizes of steamers, viz., 6,000 tons deadweight and 8,000 tons deadweight, the latter being considered suitable for an eventual Italian standard cargo boat.

Condition of Two Floodable Compartments in Cargo Boats.—The conditions imposed by the Decree of September 10, as applied to cargo vessels, were not easy to meet. It is, of course, always possible to build cargo boats with two floodable compartments by adopting a factor of 0·5 or under, without regard to the resulting bulkhead distance. On the other hand, there are limits to the length of a compartment below which it is not possible to go without inconvenience.

The first report of the Board of Trade Committee for the Subdivision of Merchant Ships, considering the question only from a structural standpoint, fixed 10 ft. as the minimum distance between two consecutive transverse bulkheads.

Of course, this space is not sufficient for a cargo boat, either from a mercantile point of view or from that of the submarine danger. In fact, though short compartments may be used for ore, coal or corn cargoes, they are not suitable for railway materials, timber, engines, &c., and cannot be adopted in an efficient design for a tramp steamer.

Moreover, taking into consideration the effect of a submarine explosion, we know that two consecutive

* Paper read before the Institution of Naval Architects, April 10, 1919.

bulkheads have to be placed at a distance greater than the average maximum length of the opening that might be caused in the ship's side by a torpedo or mine. If not complying with this condition, two bulkheads might be broken simultaneously and three compartments flooded.

Minimum Permissible Distance between Transverse Bulkheads.—After having examined many cases of torpedoed ships, we agreed upon 8 m. as a practical figure to be adopted as a minimum distance between two consecutive bulkheads.

Numerous cases of damage to torpedoed ships examined by the committee showed that the length of the breach was under the minimum distance adopted, and in the few cases in which the breach showed a greater length we considered that to ensure the destruction of two consecutive bulkheads the torpedo would have to strike just in the middle of the compartment.

Considering that the two conditions, viz., holes longer than 8 m. and the striking of the torpedo in the middle of the distance between bulkheads, would very seldom occur at the same time, the Commission accepted 8 m. for the minimum length of holds in cargo boats as a practical figure capable of complying both with war and mercantile requirements.

The Commission also suggested that some of the fore and aft bulkhead connections with the deck and sides of a ship would have to be constructed so as to be easily removed after the war.

Position of Engine and Boiler Rooms.—As is generally known, the permissible floodable lengths are longer just aft of amidships and shorter at the ends. If the most advantageous part of a steamer is occupied (as is usually the case) by engines and boilers, the cargo holds being confined to fore and aft of the engine and boiler rooms, the cargo holds will necessarily be small, and will not afford enough room for general cargo.

For this reason it was decided to place engines and boilers aft, this position being considered also safer against war risks.

Advantages of Having Engine and Boiler Rooms Aft in a Cargo Boat.—From a mercantile point of view these advantages are evident, so much so that we see every day more steamers being built with this innovation.

The advantages are as follows :—

1. Increase of the size of holds used for general cargo in the central and wider part of ship.

2. Very long tunnel shafts are unnecessary, which ensures a considerable economy of building material as well as an increase in the aft hold cargo space.

3. All loading and unloading operations are grouped, and consequently the work is more easily carried on, watched and facilitated.

4. In case of there being a deck cargo, it cannot be damaged by smoke, and fire risks are lessened.

The following advantages are also evident from the war-risk point of view :—

5. As the shaft tunnels in a vessel with engines amidships are liable to be bent in case of submarine explosion, the whole length between boiler room and stern post may be considered as a very dangerous target, whereas in a vessel with engines aft the danger zone is reduced practically to less than one-half.

6. Danger to engines and boilers is greatly reduced, because the disturbed water caused by screw action is not apt to be easily crossed by a torpedo.

Reciprocating engines aft may sometimes cause vibration, but even this inconvenience is avoided by adopting turbines as motive power, which with very short tunnel shafts are fully capable of preventing vibration.

Awning Deck Aft.—To comply with the condition of two-floodable compartments aft having a coefficient of permeability of 0·85, as adopted for machinery spaces, it is necessary to increase the height of the ship by the adoption of an awning deck (see Fig. 8, page 537), of sufficient length, having sometimes a watertight deck beneath it.

The ship must also be fitted with trimming tanks fore and aft.

Of course the placing of engine and boiler rooms aft is not free from drawbacks, but they are of no great consequence. The chief drawback is the deeper draught in an unloaded condition.

To put the ship on an even keel when unloaded it is necessary to fill the fore tanks and double bottom in order to obtain an equivalent moment of the weight of engines, boilers and bunkers; the aft tank must also be filled to compensate for the weight of coal burned during the voyage. In the empty condition there is an increase of draught of about 30 cm. in an 8,000 tons deadweight steamer, but when the ship is unloaded this can hardly be considered a disadvantage, for it is generally necessary to load an empty vessel with ballast or water to render her seaworthy.

Rules Adopted for Cargo Vessels of 8,000 Tons Deadweight.—The Commission, when concluding their work, agreed upon the following coefficients of permeability :—

For cargo holds	0·60
For engine and boiler rooms	0·80
For internal-combustion engine rooms	0·85
For passengers; officer and crew accommodation	0·95
For spaces intended for water ballast...	0·95

General Rules.—Number of cargo holds not to be less than six, besides the deep tanks and compartments at extremities.

A watertight bulkhead to be fitted between the engine and boiler rooms.

Consequently the number of watertight bulkheads is not to be less than nine, and they are to be fitted in accordance with the diagram of the two-floodable compartment ship.

Suggestions were made that—

1. Bulkheads, where required, to be fitted in such a way as to be easily taken down after the war.
2. Engine and boiler rooms to be placed aft.
3. Dimensions and scantlings of watertight bulkheads to be above the requirements of the Registro Navale Italiano.
4. Sheer to be increased.
5. Aft and fore extremities to be finer than usual in cargo boats, block coefficient not to be above 0·80.
6. Crew accommodation to be placed aft.
7. Trim to be on an even keel when crossing danger zones.

The suggestions of the British Board of Trade and Bulkhead Committee to be adopted for accessory requirements, the following being particularly insisted upon :—

1. Awning deck and forecastle bulkheads not to have any doors above deck.
2. Watertight compartments not to have any doors except where absolutely necessary, and in this case they are to be placed as high as possible, and all gear fitted so as to be worked from the deck.
3. Bunker bulkheads not to be considered as watertight.
4. Auxiliary boilers or independent oil engines to be placed above the deck so that all lighting and wireless apparatus may be kept efficient in case of emergency.
5. Bilge pipes in each compartment to be fitted with a non-return valve.
6. Rudder surface to be increased.
7. Port holes to be placed as high as possible and fitted with solid cast-iron shutters.

Vessels in Course of Construction.—To apply the above rules to steamers in course of construction or for which building material had already been gathered in the yards, there was only one thing to be done, viz., to increase the number of bulkheads in order to divide large compartments, because no alteration was possible in the design of such steamers. This arrangement was adopted by the Ansaldo Shipyards in the ships building of the "Ansaldo I" type and sister ships, as already described in *The Shipbuilding and Shipping Record*.

As shown on Fig. 8, four new bulkheads were fitted at frames 60, 83, 110 and 132, and these were made in such a manner as to be easily taken down after the war in order to double the size of each hold.

Other vessels of the "Ansaldo IV" type, of about the same dimensions, but with a slight difference in the boiler arrangement, were also to be fitted with four extra bulkheads.

For both types of steamers the permissible floodable length curve (see Fig. 9, page 537) which ensures the possibility of floating with three compartments flooded in the central part of the ship, or two at either end, may be applied.

Of course, the distance between bulkheads becomes rather short, being reduced to a minimum of 8·60 m. and a maximum of 10·60 m. in war time, and there is also a waste of material on the bulkheads to be removed after the war, their weight being from 25 tons to 30 tons each. But bearing in mind that the cargoes carried to Italy during the war in many cases consisted of coal, grain, ore and pig-iron, the lack of long compartments as well as the extra expense involved were considered worth the increased safety they would afford to the steamers.

Moreover, the National Insurance Institute having consented to grant a 15 per cent. rebate on the war risk premium for steamers built with such a subdivision, the saving of expense on this account largely compensated for the extra cost incurred for the additional bulkheads.

When the bulkheads are taken down the length of the holds in these steamers is increased to a minimum of 18·32 m., the maximum being 19·08 m.

New Steamers to be Built.—Plans designed without regard to the fact that a steamer is already in course of construction, or that her material is already in the yard, permit of better subdivision with longer compartments and fewer bulkheads to be removed after the war.

Several of the leading shipyards were requested to prepare plans for 8,000 tons deadweight cargo boats to be built under the condition of two-floodable compartments, and the choice fell upon those presented by Messrs. N. Odero fu Alessandro, Sestri Ponente. The subdivision and permissible floodable length curve, as well as the ship's trim in the different cases of flooding, are seen on the opposite page, the ship's general dimensions being as follows :—

	Metres.
Length between perpendiculars ...	115·20
Breadth	15·70
Depth to continuous deck	9·22
Load draught	7·57
	Tons.
Load displacement	11,180
Block coefficient	0·79
Unloaded ship, weight	3,180
Coal and water	690
Gross tonnage	5,750
Total deadweight capacity	8,000
Total deadweight capacity after the war	8,350
Engines—geared turbines (shaft horse-power)	2,400
Speed (knots)	10
	Metres.
Longitudinal metacentric height (displacement, 11,300 tons)	102·60
Transverse metacentric height (displacement, 11,300 tons)	1·18

As shown on the opposite page, the vessel is partially awning-decked with seven holds, the aft one being capable of being used also for bunkers.

The two extreme holds are the shortest, their length being 8·39 m. (27 ft. 5 in.).

The respective lengths of the other five holds are as follows :—

Two of 9·15 m. (29 ft. 11 in.).
Two of 12·96 m. (42 ft. 5 in.).
One of 18·30 m. (59 ft. 11 in.).

After the war, should it be considered necessary, by taking down only two bulkheads, viz., F–H or G–E, a steamer built on such a plan would afford ample cargo space for the minimum length of holds, which would never be less than 17·54 m. (57 ft. 6 in.), leaving out the fore peak and aft eventual bunker, while the maximum would measure 31·27 m. (102 ft. 6 in.), still complying with the single-floodable compartment condition.

It has already been mentioned that the awning deck must be built in order to ensure the ship's safety when engine and boiler rooms are flooded.

The weight of the empty hull is about 2,200 tons, each ton of steel employed giving a carrying capacity of 3·6 tons of cargo. Naturally, a long awning deck aft causes an increase in the space available for cargo, and consequently there is also a rise in the gross tonnage up to 5,800 tons, in this design; but this was readily agreed upon, as additional cargo space is often required for trading between Italy and South America or for carrying cotton.

Methods Adopted in Calculating the Permissible Floodable Length Curves.—For all the plans laid before the Commission the calculations were made with the common method, and also with Ing. Barricelli's, manager of the Registro Navale Italiano, and this is described in the appendix, showing its application to the "Ansaldo IV" type of ship.

Standardisation.—Fifteen different shipyards adopted the plan chosen by the Commission, undertaking to build one ship each to the same design. Thus, a great deal of building material being ready, standardisation was practically started, when the armistice was signed.

It is to be hoped that the two-floodable compartment plan will not be abandoned in the future, as it is the least that can be done to secure the floating of a damaged cargo boat, since even after the war bulkheads may still break, through the ship grounding or coming into collision—so that two compartments would be flooded and in such a case a single-floodable compartment vessel would sink.

APPENDIX I.

The problem of watertight subdivision has been investigated most comprehensively and completely by Ing. Domenico Barricelli, Director of the Registro Navale Italiano, who has indicated a method of calculation which is at once simple, rapid, and no less accurate than any other, not excepting the very laborious method proposed by the Commission appointed by the British Board of Trade. Ing. Barricelli's method has the advantage of being directly applicable to all vessels, whether already built or under construction.

Few particulars are required, and these can be obtained from the builder's plans or may be easily measured with the usual measurements for tonnage; it does not necessitate comparisons with type ships and the use of sets of diagrams or numerical tables, which is never easy, and is in any case too mechanical and too easily liable to error in practice, nor does it call for any complicated methods of correction. In a paper written by Ing. Barricelli he gives the complete proof and explanation of his method, and deals with a number of cases demonstrating that it is readily applicable to the whole of the cases examined by the International Conference for the Safety of Life at Sea, London, January 20, 1914. Without following Ing. Barricelli's investigation step by step, the following *resumé* of its essential features may be given.

1. Assuming that for all water lines comprised between the light load-line and the deepest load-line permitted by the present freeboard regulations, a suitable safe subdivision can always be found.

2. The metacentric theory is applicable, with any degree of approximation desirable, to the usual sheer-lines and margin-lines derived from them, since the angles of inclination of the limit water-lines at the ends of the vessel to the initial water-line never attain values incompatible with the correct application of the theory.

And taking :

V = the volume of hull to outside of shell at the initial water-line ;

v = the volume to outside of shell due to the extra immersion through flooding ;

Δ = the difference in draught due to flooding ;

L = the length of the vessel ;

R_1 = the longitudinal metacentric radius corresponding to the volume of hull $V + v$;

d = the distance of the point at which the volume v, and therefore the weight of the flooding water, may be regarded as concentrated, from the transverse axis through the centre of gravity of the water-line parallel to the initial water-line corresponding to the hull $V + v$; the relation between these elements will be :

$$R_1 \frac{V + v}{v} \cdot \frac{\Delta}{L} = d \quad . \quad . \quad (1)$$

By the application of this equation (1) to a certain number of limit water-lines forward and aft it is easy to find the distance d, and to find the position of the vertical concentration section and the corresponding flooding volume v when the characteristic curves of the vessel extending to the freeboard deck are available, viz. :—

The curve of volume of hull to outside of shell ;

The curves of locus γ of centres of gravity of water-lines ;

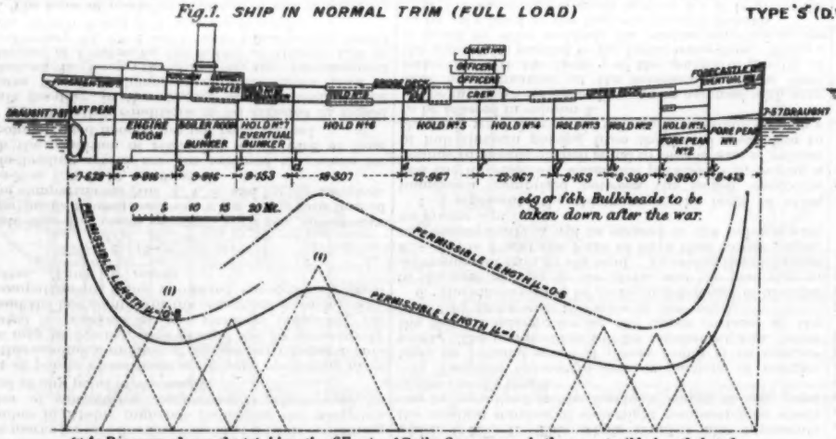
The curve of longitudinal metacentric radii ;

The curve of transverse sectional areas.

It will thus be possible to draw a curve of limit volumes

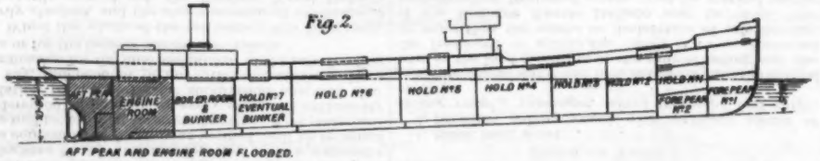
ITALIAN TWO-FLOODABLE COMPARTMENT CARGO STEAMER.

Fig.1. SHIP IN NORMAL TRIM (FULL LOAD) TYPE 'S' (D.W. 8000 TONS)



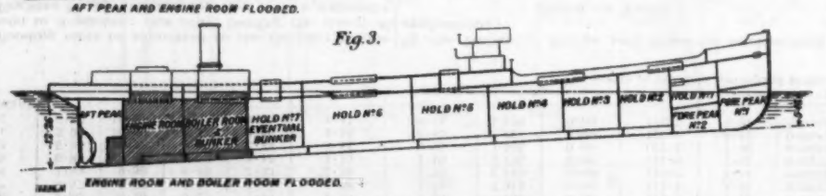
(1) As Diagram shows, the total length of Engine & Boiler Space exceeds the permissible length, but the Continuous Deck being Watertight as well as Boiler & Engine Rooms Cofferdams between Deck. The Trim with these two Compartments Flooded results as shown in Fig.3.

Fig.2.



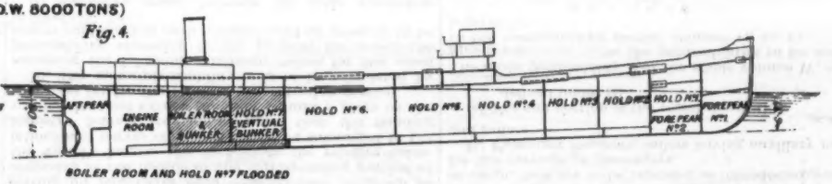
AFT PEAK AND ENGINE ROOM FLOODED.

Fig.3.



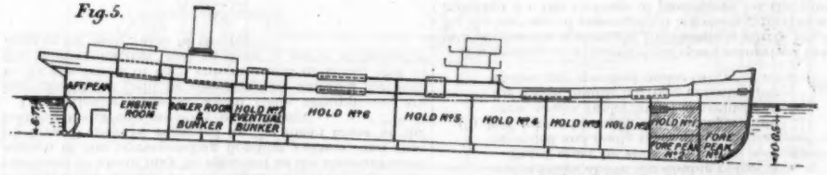
ENGINE ROOM AND BOILER ROOM FLOODED.

Fig.4.



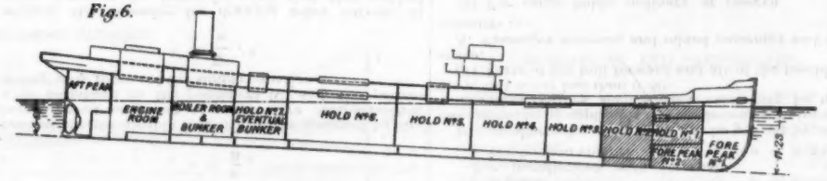
BOILER ROOM AND HOLD N°7 FLOODED

Fig.5.



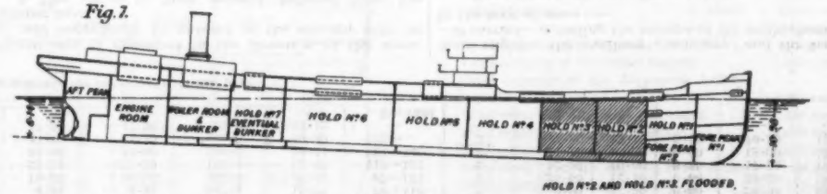
HOLD N°1 AND FORE PEAKS FLOODED.

Fig.6.



HOLDS N°1. N°2. AND FORE PEAK N°2 FLOODED.

Fig.7.



HOLD N°2 AND HOLD N°2 FLOODED.

or maximum flooding volumes admissible, for every point of the length of the vessel.

Such a curve must evidently be regarded as a true and new characteristic curve, independent of considerations of permeability or of type and arrangement of compartments, and it forms in every case the starting point for the investigation of safe flooding, whatever may be the permeability and whatever the extent, form, position, or grouping of the various compartments. From the curve of limit volumes, on the hypotheses explicitly and implicitly accepted for longitudinal subdivision by the already-mentioned Conference of London, a curve of limit lengths is immediately derived, which gives, for every point of the vessel's length, the length of the zone, having this point as its centre, which can be flooded in order to reach the corresponding limit water-line for a permeability equal to unity. From this curve the various curves of floodable lengths for different permeabilities can be drawn.

The curve of limit volumes and the curve of limit lengths present irregularities corresponding to the irregularities shown by the margin-line, which is regarded, in the most general and complete sense, as the envelope of the limit water-lines and shows at the forward and after ends, and between these, break-points or traces of the axes of rotation of the water-lines. But even in the case where the margin-line reduces itself to two points—extreme forward end and extreme after end—the method is uniformly applicable, as is clearly set forth in Ing. Barricelli's paper.

By following the rules laid down on a printed form prepared by Ing. Barricelli for the R.N.I., the method has already been tested by Italian shipbuilders and found to be completely satisfactory, and to give exactly the same results as those given by the long and laborious process of the Board of Trade.

The example of its practical application to the case of the steamships Ansaldo II, Ansaldo III, Ansaldo IV, built by Messrs. Ansaldo and Co., of Sestri Ponente, will be sufficient to show how simply and rapidly the problem of safe subdivision can be solved for any type of vessel without recourse to other complicated methods, whether comparative or direct (see page 537).

APPENDIX II.

INSTRUCTIONS.

A. The following plans are to be submitted to the Registro Navale Italiano, together with the sheet of particulars (Table I, page 536):—

1. Characteristic curves of the hull for water-lines parallel to the initial water-line, extending to the corresponding limit water-line.

(*a*) Curve of volumes of hull to outside of shell.

(*b*) Curve of areas of water-lines to outside of shell.

(*c*) Curve of longitudinal metacentric radii.

2. Floodable curves.

(*a*) Longitudinal profile of the hull extending to margin-lines or portions of margin-lines, or to the highest water-line of sets of limit water-lines. This profile should for preference be drawn to a contracted scale, having the scale for depth twice that for length, and must show:—

Sufficient figured dimensions to determine the above-mentioned limits of flotation.

The vertical passing through the $\frac{1}{2}$ L.

The initial water-line.

The locus γ of the centres of gravity of water-lines parallel to the initial water-line.

The limit water-lines indicated in column 1 of the sheet of particulars (Table I).

The positions of the transverse watertight divisions.

The verticals through the concentration section of each compartment or group of consecutive compartments as given by column 16 of the sheet of particulars.

The verticals through the middle of the length of each compartment or group of compartments (if not coincident with the preceding).

(*b*) Curves of limit volumes (v) (v), deduced from the particulars given in columns 5 and 11 of the sheet of particulars.

(*c*) Curve of areas B of transverse sections to outside of framing to the limit water-lines, deduced from the particulars given by columns 11 and 12 of the sheet of particulars.

(*d*) Curve of limit lengths (λ) (λ) deduced from the particulars given by columns 11 and 13 of the sheet of particulars.

These curves are to be drawn below the longitudinal profile mentioned above and the verticals mentioned in (*a*) are to be drawn through them.

3. Supplementary curves or calculations or other elements in the investigation of safe flooding.

B. The calculations and plans relating to the safe flooding presented to the Registro Navale Italiano by the builders or other interested party must bear the definite statement, duly signed, that the whole of the particulars contained therein have been carefully measured from the mould loft or from actual measurements on board of the vessel, and are in entire agreement with the measurements taken. The builders or other interested party will be under obligation to give every assistance to the Registro Navale Italiano in checking the particulars and to submit to the Registro Navale Italiano all other plans, calculations, or documents if requested, as, for example, the profile and deck plans, the loft-offset book, &c.

3. The sheets of particulars and the curves relating to

TABLE I.—Italian Two-Floodable Compartment Cargo Steamer.

Registro Navale Italiano (R.N.I.). Safe longitudinal subdivision with one or more consecutive compartments flooded. Table for use in drawing the diagrams and for obtaining the Conditions of flooding of (1)* steel hull of the (2) standard cargo-boats. Flag: Italian. Name: Ansaldo II, III, IV. Owner: Societa Nazionale di Navigazione. Builder: Gio Ansaldo and Co. Place and year of construction: Sestri Ponente, 1917–18. Dimensions: 114·92 × 15·70 × 9·47. Builder's No.: 189—224—246. No. in Registry: 756—757—1,129. Erections: .....

Length of hull: L = 115·345 m. (Including stem and stern-post at initial water-line.)

Initial water-line (3). Draught moulded forward, 7·32 m.; aft, 7·32 m.; mean, 7·32 m.

Initial displacement volume, V = 10,865 cub. m. (Outside shell plating.)

Subdivision coefficient, K = 0·50 and 0·333. $K' = CK = \left\{ \begin{matrix} 2 \times 0{\cdot}5 \\ 3 \times 0{\cdot}333 \end{matrix} \right\} = 1$ (4).

Block coefficient, ϕ = 0·817.

1. Limit-Water-Lines (5).* Number.	2. Draughts (Moulded). Aft. m.	Forward. m.	Mean. m.	Trim. m.	3. Trim due to the Flooding, $\Delta = \delta' - \delta$ (6). m.	4. Increase of Immersion at Intermediate Water-Line (7), s. m	5. Limit-Volume, V. m³	6. Longitudinal Position of Centre of Gravity of Layer (s) from $\frac{1}{2}$ L d_1. m.	7. Longitudinal Metacentric Radius at Intermediate Water-Line, R_1. m.	8. Ratio, $\frac{V+v}{v} = m$.	9. Ratio, $\frac{\Delta}{L} = n$.	10. Product, $R_1 \times m \times n = d$. m.	11. Longitudinal Position of Concentration Section from $\frac{1}{2}$ L $d' = d + d_1$ (8). m.	12. Area (Outside Frame) of Concentration Section at Limit-water-line, B. m².	13. Limit Length, $\left(\begin{matrix}\mu = 1 \\ K' = 1\end{matrix}\right) \frac{V}{B} = \lambda$ (9). m.	14. Limits of Compartments or Group (the Number of Frame or the Distance in m. from Aft P.P. to be Indicated).	15. Number of Compartments included in the Group. No.	16. Distance of Concentration Section from $\frac{1}{2}$ L. m.	17. Length resulting from Diagram, (A) (A) λ. m.	18. Mean Permeability, (10), μ.	19. Admissible Length, Length. $\frac{K' \lambda}{\mu} = \lambda'$. m.	20. Effective Length λ''. m.
Aft—																Aft					
1	11·35	5·40	8·37	5·95	5·95	1·05	1,735	0·00	121·0	7·26	0·0516	45·33	−45·33	115·0	15·10	— 28	2	−47·90	16·60	0·85	19·55	19·51
2	11·21	5·69	8·45	5·52	5·52	1·13	1,855	0·00	120·0	6·86	0·0719	39·43	−39·43	135·0	13·74	15— 37	2	−39·70	13·75	0·80	17·20	16·76
3	10·95	6·25	8·60	4·70	4·70	1·28	2,105	0·00	118·5	6·16	0·0407	29·71	−29·71	150·0	14·03	28— 48	3	−30·60	14·00	0·69	20·30	15·24
4	10·68	6·81	8·75	3·87	3·87	1·42	2,335	0·00	117·0	5·65	0·0336	22·22	−22·22	149·0	15·67	37— 72	3	−18·00	16·70	0·60	27·80	26·67
5	10·30	7·60	8·95	2·70	2·70	1·63	2,675	0·00	115·0	5·06	0·0234	13·62	−13·62	147·4	18·15	48— 93	3	− 9·50	19·55	0·60	32·50	20·67
6	9·80	8·70	9·25	1·10	1·10	1·93	3,160	0·00	112·0	4·44	0·0095	4·73	− 4·73	147·4	26·43	60— 97	3	+ 0·40	22·90	0·60	38·15	28·19
7	8·57	9·63	9·10	1·06	1·06	1·78	2,915	0·00	113·5	4·73	0·0092	4·95	+ 4·95	147·4	19·77	72—110	3	+ 9·90	17·36	0·60	28·95	28·95
8	7·53	9·86	9·69	2·33	2·33	1·37	2,245	0·00	118·0	5·84	0·0202	13·92	+13·92	147·4	15·23	97—121	2	+23·65	12·10	0·60	20·20	18·29
9	6·85	10·00	8·42	3·15	3·15	1·10	1,795	0·00	121·0	7·05	0·0273	23·29	+23·29	147·4	12·18	110—132	2	+32·90	10·60	0·60	17·65	16·76
10	6·35	10·19	8·27	3·84	3·84	0·95	1,555	0·00	122·5	7·99	0·0333	32·60	+32·60	146·5	10·61	121—146	2	+41·10	10·80	0·60	18·00	17·83
11	5·94	10·40	8·17	4·46	4·46	0·85	1,425	0·00	123·0	8·62	0·0387	41·10	+41·10	132·0	10·80	132—	2	+47·20	13·12	0·68	19·30	10·16
12 Forward	5·86	10·27	8·06	4·41	4·41	0·74	1,220	0·00	124·5	9·91	0·0383	47·20	+47·20	93·0	13·12	— Forward	—	—	—	—	—	—

* The figures in brackets correspond to the numbers of the notes given on this page.

the flooding must be submitted to the Registro Navale Italiano in duplicate; one copy, bearing the stamp of the Registro Navale Italiano, together with a statement of the conditions of flooding as verified, will be returned to the builder or other interested party. This statement is understood to be made in every case, and exclusively in relation to the particular subdivision adopted, that is to say, independent of any other condition, subject to verification for the final assignment of the safe-flooding marks or for the issue of similar documents.

D. When the whole of the calculation has been satisfactorily checked, and the above-mentioned verifications satisfactorily carried out, the Registro Naval Italiano will assign the safe-flooding marks and will state them on the classification certificate or in the register book, or will issue a special certificate.

The marks for safe flooding consist of a circle containing a number in Arabic numerals indicating the minimum number of consecutive compartments which may be flooded at any point of the length.

But at points where there are groups containing more than this minimum number of consecutive compartments which may be flooded, such groups will be successively indicated in brackets by two numbers indicating the first and the last compartments comprised in each group, the compartments being numbered consecutively from the stem. Thus the marks :—

2 (3–5) (7–10)

indicate that the vessel can float with two consecutive compartments flooded, and also when the groups formed by the compartments Nos. 3, 4, 5, and by the compartments Nos. 7, 8, 9, 10, are flooded.

Safe-flooding marks are not assigned to vessels for which the condition of remaining afloat with at least one compartment flooded has not been verified.

E. For the other conditions to be satisfied in regard to safe flooding, in the absence of regulations of the Registro Navale Italiano, or of Government laws or regulations in force, the rules of the International Conference of London on the Safety of Human Life at Sea—January 20, 1914—and those subsequently issued by the British Board of Trade, are to apply.

F. The issue of marks or evidence of safe flooding by the Registro Navale Italiano does not imply recognition by the Italian or foreign authorities for international application.

Notes on Table I.

1. Steel, iron, wood . . .

2. Steamer, sailing vessel with auxiliary motor or sailing vessel; passenger, mixed passenger and cargo, or cargo.

3. The initial water-line here indicated fixes the normal trim in the load condition at the time of sailing and also the freeboard to which the vessel is to be restricted in order that the marks or declaration of safe flooding of the Registro Navale Italiano may be valid. The corresponding freeboard marks must be marked on the ship's side.

4. The coefficient K′ will be deduced from K by assuming for C the nearest whole number above it for which C K $\geqq$ I. This whole number also represents the smallest number of watertight compartments which can be permitted in the floodable length at any point of the vessel's length.

5. Tangents to margin-lines or portions of margin-lines, or forming series of planes round given margin-point. The margin-lines will be assumed at 3 in. below the line of intersection of the upper surfaces of the bulkhead decks with the sides of the vessel.

6. The minus sign to be given to differences of draught in the case of trim by the stern, and the plus sign to differences for trim by the head. In taking the difference $\delta' - \delta$, the δ' and the δ are to have their proper signs, and consequently Δ will be entered in the column with its proper sign.

7. δ represents the thickness of the layer of extra immersion, comprised between the initial water-line and the intermediate water-line parallel to it, having a volume to outside of shell equal to the increase of volume of hull through passing from the initial water-line to the limit water-line; this volume is the limit volume v to be entered in column 5.

The intermediate water-line can be assumed with very close approximation, at the intersection of the limit water-line with the locus γ of the centres of gravity of the water-lines parallel to the initial water-line. When s is found by other methods the relative calculations are to be submitted to the Registro Navale Italiano.

8. The same sign is given to d as Δ; d is given the plus sign if measured in the direction of the stem and the minus sign if measured in the direction of the stern, d' will accordingly be entered in the column with its proper sign.

9. The curve of limit lengths deduced from the equation

$$\lambda = \frac{v}{B}$$

enables the permissible length λ' to be assigned to any compartment or group of consecutive compartments, with variations in the coefficient K′ and the permeability μ by means of the simple equation :

$$\lambda' = \frac{K'}{\mu} \cdot \lambda$$

without the necessity for drawing other curves. It must, however, be borne in mind that this method assumes (in favour of the safe flooding) that the transverse section at the middle of the length of the relative compartment or group may be regarded as the concentration section of the corresponding flooding volume, and that its area B may be regarded as the mean areas of the relative transverse sections of flooding.

In particular cases in which these assumptions are inadmissible it will be necessary by suitable methods to fix the limits of each compartment or group and so the relative lengths, and to draw a curve of floodable lengths for each value of the ratio :

$$\frac{K'}{\mu}$$

setting off lengths of each compartment or group as ordinates at the middle of the corresponding portion of the vessel's length. In such cases the relative calculations and curves employed are to be submitted to the Registro Navale Italiano as proof that the flooding volume does not exceed the limit volume v given by the curve (v) (v) for the relative concentration section.

10. The mean permeability μ is to be calculated by assuming the following minimum values for the mean permeability according to the purpose for which the spaces contained in each compartment or group is to be utilised :—

(i) Machinery space—between the main transverse watertight bulkheads bounding the spaces containing the main engines, the auxiliary machinery, and the boilers—if carried—including the volume of the double bottom s in the way of same :—

For installations with steam engines ... ... $\mu = 0{\cdot}80$

For installations with internal-combustion engines ... ... $\mu = 0{\cdot}85$

If a smaller value than 0·85 can be proved by direct calculation to be applicable to installations with internal-combustion engines, such smaller value may be taken for μ, but never less than 0·80.

(ii) Parts of the hull forward and aft of the machinery space.

A. Passenger steamers and mixed passenger and cargo steamers :—

(a) For cargo holds, ordinary or reserve bunkers, stores, baggage spaces, chain lockers, shaft or pipe tunnels, fresh-water tanks above the double bottoms $\mu = 0{\cdot}60$
Proof must be shown that the said spaces are intended and really utilised for the purpose stated.

(b) For spaces intended for passengers and crew, peaks, tanks intended exclusively for water, double bottoms and all other spaces not specified under (a)... ... $\mu = 0{\cdot}95$

If a portion of a 'tween-deck space comprised between two permanent watertight bulkheads is partly employed for the carriage of passengers it is to be regarded as wholly intended for the carriage of passengers for the purposes of the calculation for mean permeability. If portions of 'tween-deck spaces are intended for either passenger or cargo, they are to be regarded as intended exclusively for the carriage of passengers.

B. Passenger steamers, sailers having auxiliary motors and sailers :—

(c) For any portion of the vessel except that defined under (i) ... ... $\mu = 0{\cdot}60$

The mean permeability μ of the whole volume W, taking $\mu_1, \mu_2, \mu_3, \ldots$ as the permeabilities to be assigned to the corresponding partial volumes $v_1, v_2, v_3, \ldots$ is given by :

$$\mu = \frac{\mu_1 v_1 + \mu_2 v_2 + \mu_3 v_3 + \ldots}{W}$$

ITALIAN TWO-FLOODABLE COMPARTMENT CARGO STEAMER.

(For Description, see Page 533.)

Fig.8. TYPE "S" ANSALDO II, III, IV.

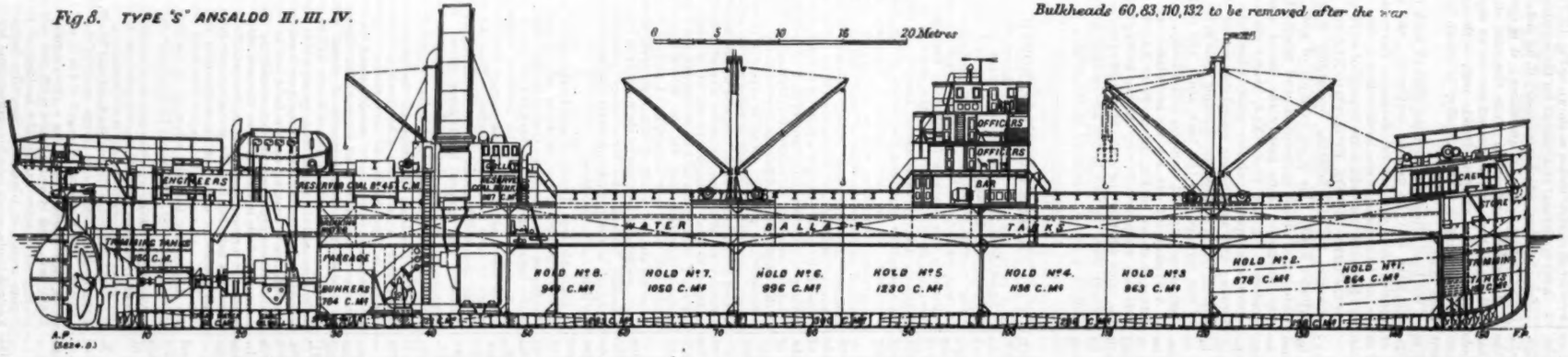
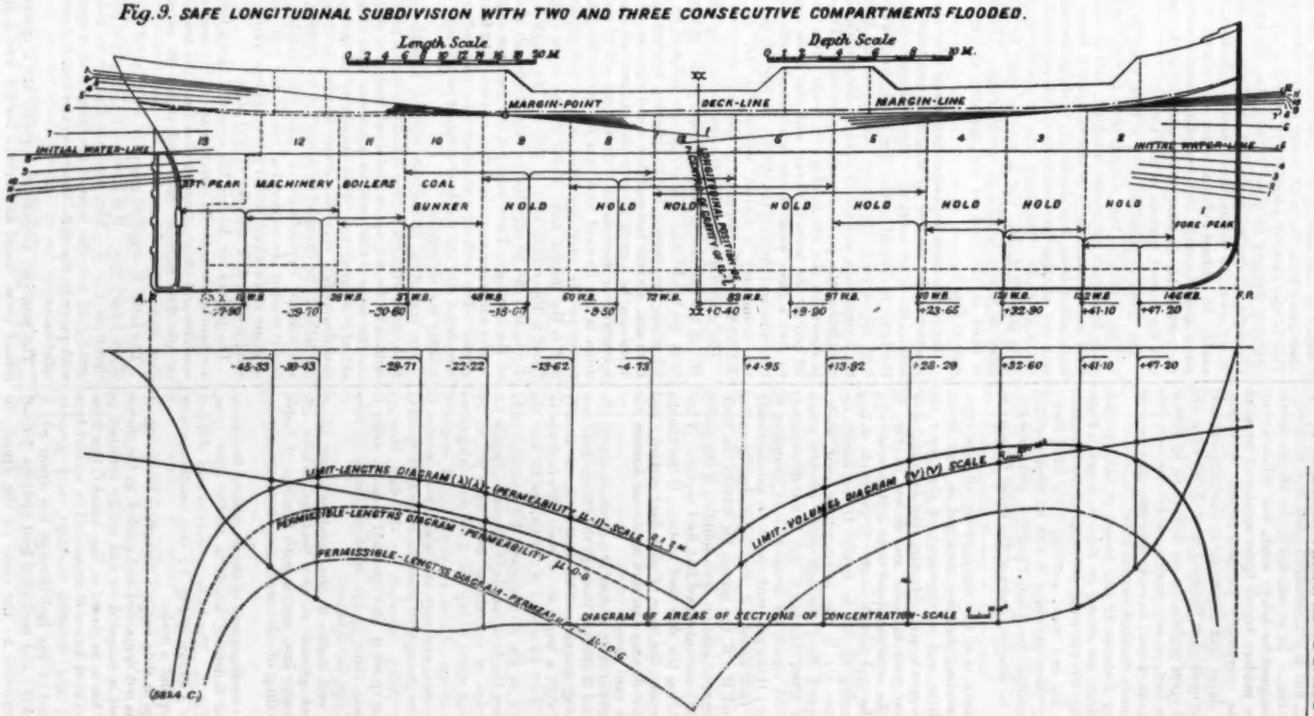


Fig.9. SAFE LONGITUDINAL SUBDIVISION WITH TWO AND THREE CONSECUTIVE COMPARTMENTS FLOODED.



DIMENSIONS AND PARTICULARS.

Length extreme	119·85 m.
Length between perpendiculars	114·92 m.
Breadth moulded	15·70 m.
Depth moulded	9·47 m.
Load draught	7·42 m.
Displacement loaded	11,280 tons
Engines—geared turbines	2,200 S.H.P.
Gross tonnage	about 5,300 tons (registered)
Deadweight carrying capacity	8,000 tons
Total capacity of the double bottom	1,316 cm.
Total capacity of the deep-water ballast tanks	1,564 cm.
Total capacity of the trimming tanks	330 cm.
Total capacity of the water ballast	3,088 cm.
Total capacity of the cargo holds	8,033 cm.
Total capacity of the drinking-water tanks	60 cm.
Total capacity of the spare feed	122 cm.
Total capacity of the coal bunker	784 cm.
Total capacity of the reserve coal bunker	744 cm.

CONTRACTS.—With reference to our note under this heading, on page 439 *ante*, we are now informed that the condensing plant in the contract of the English Electric Company, Limited, for the Glasgow Corporation, will not be of the Willans surface type, with duplicate air-extraction plant on the Willans' rotary water-jet system. It was ultimately decided by the corporation engineer to put down the Mirrlees Watson surface-condensing plant with duplicate Mirrlees Leblanc multi-jector type of air pump. Each airpump unit will consist of four ejectors, one or more of the latter being operated, according to the amount of air to be dealt with.

NAVAL HONOURS.—The following honours have, with the approval of His Majesty the King, been conferred upon naval engineers, among others. For valuable services rendered in connection with the war: To be O.B.E., Military Division, Engineer-Commanders A. G. Bremner, R.N., T. R. Tyler, R.N.R., and H. J. Bowden, R.N.R.; Engineer-Lieutenant H. S. Hoar, R.D., R.N. For services in action with enemy submarines: To receive the Distinguished Service Cross, Engineer-Lieutenant G. H. Prescott, R.N.R. For services on the Mediterranean Station: Mentioned in Despatches, Engineer-Commander W. J. Blackford, R.N.R., Engineer Lieutenant-Commander Stanley Harris, R.N.R., Acting Engineer-Lieutenant G. J. Privett, R.N., and Acting Chief Engine-Room Artificer R. J. Goodman. For services in ocean escorts: Mentioned in Despatches, Engineer-Commanders Richard Mather, R.N.R., John Mackenzie, R.N.R., Richard Thomas, R.N.R., and C. B. F. Le Warn Rock, R.N., Engineer-Lieutenants John Holden, R.N.R., and J. B. Inverdale, R.N.R., and Chief Engine-Room Artificer J. J. Beer. For miscellaneous services: To receive the Distinguished Service Medal, Chief Engine-Room Artificer H. B. Broomhead. Mentioned in Despatches, Chief Engine-Room Artificers S. T. Bell and C. P. Leven.

THE FAY LATHE.

We illustrate on Plates XXXVIII to XLI and on page 540, a new type of lathe which is being manufactured by the Jones and Lamson Machine Company, of Springfield, Vermont, U.S.A. This lathe—known as the "Fay" lathe—is at present being made in two models: (*a*) The standard automatic lathe shown in Fig. 1, Plate XXXVIII, and (*b*) the automatic bevel gear or chucking lathe shown in Fig. 2. The first-named type is intended for dealing with parts which can be supported for turning and facing operations upon centres or mounted upon an arbour. This lathe will swing 14 in. over the bar, or 11 in. over the slide or carriage, with a maximum length of 17 in. between centres, and is capable of turning up to 10 in. in length. The second, or (*b*) type of lathe is the standard lathe altered to produce ring bevel gears for automobile rear axles. This lathe will chuck blanks up to 14 in. diameter over the bar, 11 in. over the carriage, and up to 6 in. in length.

The Fay lathe is a modification of the ordinary engine lathe, in that it is a highly-specialised automatic machine for manufacturing standard parts; it is a second-operation machine, and suitable for straight, taper and former turning, straight and bevel facing, and recessing, but is not arranged—nor is it suitable—for screw-cutting. It is automatic in all its movements and designed for heavy work, but will not compete with the modern turret lathe employed on work which can be completely finished in one operation. The makers claim that the lathe is the simplest and most accurate method of finishing work if the work can be supported upon centres, on an arbour, or by means of a chuck, in fact, on any work in which the new cuts or remaining operations have to be concentric or true with a previously finished central hole.

The leading features of the design of this special-purpose machine are shown in Figs. 3, 4 and 5, Plate XXXIX. Fig. 3 is the front elevation of the standard lathe, Fig. 4 the end view, and Fig. 5 the back view; on examining these drawings it will be seen that the lathe is a departure from usual practice, and we therefore propose to describe some of the novel features in detail.

The headstock is of the single-pulley all-gear type, with the operating handles arranged in the front. The main drive and arrangement of the gears for changing the speeds and obtaining the fast and slow variable speed feed motions are shown in Fig. 6, where A are the constant speed tight and loose driving pulleys; B the first motion shaft; C the triple sliding gear for changing speeds by hand; D the handle for changing gears C; E the intermediate gear shaft; F the slow-speed drive through silent ratchet which operates only when clutches G and H are disengaged; G the gear with clutch for automatically changing to medium speed; H the gear with clutch for automatically changing to fast speed; J the collar for operating clutches G and H; K the pinion for driving the main spindle; L the spur gear on main spindle; M the pulley for driving the constant-speed fast feed motion; N the pulley for driving the slow-feed motion; O the change gears for varying the rate of slow-feed motion; and P the shaft for driving the slow-speed mechanism for operating the cam drum.

The first motion shaft B runs at a constant speed, the change of speed is effected through the change gear-box in the following manner: The shaft B is, as already stated, fitted with a triple set of gears C, which can be slid along the shaft by means of the handle D, but the special feature is the arrangement for automatically changing—after the best speeds of the main spindle for any given series of operations have been set up by hand—from one speed to any one of the remaining three speeds in the group. These are slow speed F operated by a silent ratchet, and only available when clutches G and H are in the disengaged position, or medium speed G through the clutch operated by the cam through collar J, or fast speed H, also operated through collar J. By these means three groups of three speeds or nine speeds in all can be obtained.

The gears and shafts in the headstock are all of hardened steel ground at the bearings, whilst the spindle is a heavy iron casting with bearings of ample area. The oiling of the gears and bearings is continuous.

The general arrangement of the equalising face-plate drive and the tailstock, which is of the solid type, is shown in Fig. 3. The lathe is started and stopped by the handle Z shown in Fig. 3; this handle operates the belt shifter and a brake.

The carriage or slide rest is a departure from current practice; it is not supported and guided on the shears of the bed, but is mounted on and solidly clamped to a heavy steel bar *a*, as shown in Fig. 3 and 7, free from the bed. The steel bar *a* is supported in special lugs on the head and tailstock castings, and projects beyond the end of the bed through the drum which gives the forward and backward feed motions derived from and controlled by the cams on the drum. In Fig. 7 is shown a section of the carriage clamped on to the bar *a*.

In order that the lathe may produce straight, taper or curved work, the front end of the carriage is free, and rests on the hardened former shown at *b* in Figs. 3 and 7, through a pivoted shoe *c*; the tools in the tool-box will thus reproduce the contour given to the upper surface of the former *b*. As it is necessary that in a fully automatic lathe the cutting tool or tools should be withdrawn from the work before the return stroke of the carriage is commenced and thus prevent scoring the finished surface, an important addition has been introduced. It is shown diagrammatically in Figs. 9 and 10, Plate XL, where *e* is an adjustable way or guide pivoted on the bed at *f*. This guide is fixed to the bed after the screws *g* have been set to give the required inclination, and therefore the clearance.

The action of this mechanism is briefly as follows: When the former *b* is in the position shown by the full lines in Fig. 9, the carriage feeds forward from position 1 to position 2, when the cut will be complete; the former slide *d* is then shifted by the cam-operating rod *h* to the position shown by the dotted lines, the top of the former *b* will still be level, but due to the inclination of the guide *e* it will be lowered in this case $\frac{3}{4}$ in., thus allowing the tool to draw away from the work ready for the return stroke. This is the method adopted for relieving the tool on ordinary straight or taper turning, the mechanism is the same for curved work, but the former is relieved or cut away to obtain the clearance; further, it will readily be understood that other movements may be given to the carriage, the controlling constituents being the permissible amount of rise and fall of the carriage and the correct contour of the former.

The lathe is provided with a back arm, as shown in Figs. 5 and 11, this is equivalent to the cross slide on a turret or automatic machine, and is complete with a tool-box. It is mounted upon a heavy steel bar distinct from, but similar to, that for the carriage, and the motions are controlled and regulated from the cam drum. The back arm is usually employed upon straight facing, but it may be used for straight taper or former turning in special cases. The former is fixed at the back of the machine and is clearly seen in Fig. 5.

One of the most important deviations from accepted practice is the method by which the machine is made automatic in all motions. The automatic control of the lathe is centred in the cam drum, from which the feed movements, the speed variations, the travel of the former slide and the stopping of the machine on the completion of a piece of work are derived. The drum is shown on the left in Fig. 18, page 540; in Figs. 19 and 20 the lathe is shown with the drum removed to give a clear view of the mechanism controlled by the cams and dogs on the drum; in Fig. 21, page 540, the drum only is shown, whilst Fig. 14, on Plate XXXIX, is a development of the cam drum.

The dogs for operating the speed-changing clutches are on the exterior of the drum and at the end remote from the headstock. These dogs are followed by those for giving movements to the relieving mechanism, the back arm, and the fast and slow-speed motions; all these cams can be tuned to give any desired sequence of operations or movements. On the interior of the cam drum is the forward feed cam for giving longitudinal travel to the carriage; this cam is non-adjustable, and is the master from which all the other cams are timed; the return cam is also on the inside of the drum, and can be adjusted to vary the length of stroke of the carriage. Two cams for the feed are supplied, one for a maximum stroke of 6 in. and the other for 10-in. stroke. The cycle of operations on a piece of work is completed and the machine stopped on the cam drum making one revolution.

For repetition production work a separate drum, with cams arranged for the manufacture of a particular unit, may be set up and retained ready for mounting on the lathe; this will be apparent from Fig. 21, already referred to. This possibility of exchanging cam drums is a very important feature, as it enables the lathe to be changed from one job to another, with a minimum expenditure of time and trouble. In fact it renders the economical use of the tool possible in many cases which would not otherwise warrant the employment of a machine of that class.

The pulleys for driving the constant speed fast-feed mechanism through the clutch Q are at the back of the machine and obtain their motion from the bevel gears on the first motion shaft and pulley M, shown in Figs. 3, 5 and 6.

The lathe is supplied complete with an oil pump R of the rotary type; it is fixed to the bed in the position shown in Fig. 5. The reservoir for the emulsion of cutting oil is in the base of the lathe, and is complete with pipes to the distributors on the tool-boxes and a relief valve.

The principal accessories required are a substantial arbour press, stand and arbour holder, and a grinder for trueing up the centres, the latter is fixed in the tool-box of the carriage, and should be driven direct by a small electric motor as shown in Fig. 13, Plate XLI. A useful additional attachment for the standard lathe is a compound rest, which is necessary if, for instance, bevel facing is to be done in quantities; it is operated by a direct-feed mechanism from the cam drum, and will do all that the compound rest on an engine lathe will do. The compound slide rest, with mechanism for operating it automatically, is shown in Fig. 16, Plate XLI.

We have already stated the class of work for which the lathe may be usefully employed; the variety is considerable, and several examples have been given to us from which we have selected two differing in character, but which are typical of work performed on the lathe. In Fig. 15, on Plate XLI, the tools are arranged for the finishing operations on an engine cylinder head; this is an example of work in which accuracy of finish is essential, and where the output was so great as to justify the use of special tool-holders. Fig. 17, Plate XLI, shows the machining operations upon a cluster gear, where the turning, forming and shouldering operations are of the heavy cutting order, and require multiple tools in the tool-box of the carriage and the back arm; the tools in this case are set up and clamped individually.

A typical lay-out for an installation of standard lathes is shown in Fig. 12, on Plate XL, the lathes in this case are motor-driven, but the leading features are the same whether the drive is by belt or motor. It will be seen that the two lathes are erected in such a way that they may be operated by one man.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The steel works in the West of Scotland are busily employed, ship and boiler plates being in great demand, and while the bulk of this work is required for the home markets, quite a respectable tonnage is now available for export. Sectional material, however, is still scarce, and the want of it is being distinctly felt by consumers. Despite all the activity the uneasiness regarding the future grows, rather than decreases, as the days approach the date on which Government subsidies will be withdrawn, and a substantial all-round increase of price intimated. At the moment only the most urgent business is being put through, makers and consumers alike going warily in view of the great changes which must take place. Steel-making is such an important branch of industry in the Glasgow area that its future development in the markets of the world means either much prosperity or something decidedly the reverse. Steel is urgently needed everywhere, and if the question of rates can be satisfactorily settled a long era of brisk business will be assured. The difficulty is, of course, whether export buyers will be inclined to deal in angles priced at or about 16*l.* 10*s.* per ton; ship plates at 17*l.* or thereabouts; and boiler plates at anything from 18*l.* 10*s.* to 19*l.* per ton. Time alone will tell, and meantime American competition must be strictly watched, although even already there is a considerable increase in the number of inquiries from overseas' buyers who have every confidence in the integrity of the British manufacturer and the quality of the material he produces.

Malleable Iron Trade.—Considerable activity prevails in the malleable iron industry with plants running steadily at full pressure. Owing to the heavy demands of the home consumer, makers are not yet in a position to do much catering for the overseas' buyer who still has to stand aside and await a more favourable opportunity to have his needs satisfied. With the settlement of the labour difficulties arrears are being well met, and deliveries are almost level once more. While new business, of course, hangs fire meantime, there are extensive orders on hand for bolt, nut and rivet iron.

Scotch Pig-Iron.—Perhaps in the pig-iron industry almost more than in any other branch of the steel and iron trade, the feeling of uncertainty regarding the withdrawal of Government subsidies and the consequent increase of prices, is most intense, the change affecting as it does the vital interests of metal manufacture generally. What the ultimate result will be is difficult to forecast and the unfortunate point is that the increase should have come at a time when American and Japanese competition is making such a bold bid to capture our trade. Certainly hematite at something like 9*l.* 5*s.* per ton—which is spoken of as the new rate—may give cause for serious consideration, but as things are there seems no help for it. No price has yet been fixed for other grades of iron, but no doubt they will all come into line. As very little export has been done lately, the chances are that the advance, in the first instance, at any rate, will only apply to the home markets.

New Clyde Shipping.—Several new vessels have been launched on the Clyde during the past few days, perhaps the most important being the Glenade, a twin-screw motor ship built by Messrs. Harland and Wolff, Limited, at their Govan shipyard, to the order of the Glen Line, Limited. With an overall length of 420 ft. and a breadth of 54 ft., the new vessel has a gross tonnage of about 5,000 tons, and is being fitted with two sets of Diesel oil engines constructed by the builders at their Diesel engine works in Glasgow. Specially designed for the Eastern trade, every possible arrangement has been made to facilitate the rapid loading and discharge of cargo.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The somewhat easier conditions in the South Yorkshire iron and steel trades, following a record burst of activity, made it possible for a longer holiday than usual. Most of the steel-producing concerns set down on Friday, and did not reopen until this morning, whereas two or three days has generally been the recognised holiday. Manufacturers have a moderate amount of business to go on with, but the difficulty in estimating the extent of the upward trend of prices of basic material, makes it difficult for them to close with inquiries for contract business extending many months ahead. The general opinion is that the withdrawal of subsidies will cause Derbyshire pig-iron to advance 45*s.* to 50*s.* a ton, and hematite pig-iron by about 55*s.* to 60*s.* a ton. This will bring the price of foundry irons to about 8*l.* 5*s.*, and, as a result, finished steels will advance anything from 3*l.* 5*s.* to 5*l.* per ton. Inquiries for deliveries on export account are numerous, but the amount of business booked is not very promising. Manufacturers, however, seem fairly confident that increased activity will result when prices become more settled, though with values of basic materials in the ascendent the enterprise of American firms in cultivating home markets is a factor to be considered. Armament departments have only a small volume of work on hand. Activity is greatest in the manufacture of railway materials, axles, tyres, &c., and some satisfactory orders for tramway points and crossings, and manganese steel trackwork have been booked. Inquiries for shipbuilding material are rather more numerous, but contracts are being held up by labour uncertainty. Crucible steel makers are continuing to work half time. India, South Africa and South America are taking a fair tonnage of steel, chiefly for railway repair and construction, and business with the Scandinavian markets is improving. Despite the uncertainty of basic prices, a better demand is arising for billets, slabs and blooms. Tool steel is an active section, and a satisfactory expansion of trade is predicted if the prohibitions of the French and Italian Governments can be removed. Strong effort is being made in that direction. On home account, the demand for tool steel is of a healthy character, and rolling mills are busily engaged. All the lighter branches are well employed. Edge tool makers, and makers of files and saws, are well booked up, and are assured of steady activity for some months ahead. A feature of the current trade situation is the increased demand for agricultural implement parts, and agricultural and gardening tools.

South Yorkshire Coal Trade.—As many of the local manufacturing concerns worked for a few days on their fuel reserves during the set-down at the pits, the manufacturing demand is particularly strong. At the moment, the supply of all descriptions of steam coal fall short of requirements, and the small tonnage on offer in the open market is readily snapped up at maximum prices. Manufacturers are specially anxious to improve their reserves, as an increased export business in steam fuels to Continental consumers is anticipated when production at the pits gets into full swing. Slacks, which have been rather scarce, are in rather better supply now that collieries are not reserving extra tonnages for their own special requirement, but the bulk of the output is taken up by deliveries on contract account. The advent of warmer weather has rather eased the situation in the house coal section, and merchants are hoping to bring deliveries up to date within the next few weeks. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holiday-making has been general, and as yet it is difficult to ascertain anything now concerning the Cleveland pig-iron trade. It is gratifying to notice, however, that the disinclination to purchase forward on home account which was so noticeable when makers first made known their minimum quotations for May and June, is disappearing, and a good home business to the end of the first half of the year appears to be assured. Foreign forward demand is heavy. Neutrals are very keen to place orders, and if iron is available, very extensive transactions with customers abroad may be looked for. The iron most needed by neutrals, however, is Cleveland foundry sort, and that quality is as scarce as ever. Makers fixed minimum prices for both home and foreign business over May and June are 140*s.* for No. 3, No. 4 foundry and No. 4 forge Cleveland pig-iron, and 144*s.* for No. 1.

Hematite Iron.—Supply of East Coast hematite is very ample, and a steady trade is passing on home and foreign account, though as regards the latter, business is still hampered by difficulties in the way of arranging credits. Transactions over the next two months are reported at 172*s.* 6*d.* for mixed Nos. and 175*s.* for No. 1, and these are rates buyers at home and abroad are prepared to pay.

Manufactured Iron and Steel.—Many manufacturers are taking advantage of extended Easter holidays, to carry out repairs and renewals. Producers have good order books, but new business is rather quiet. The opinion prevails, however, that orders will come in at the advanced rates. To home customers, manufacturers have fixed the following prices to rule as from May 1:—Steel ship, bridge and tank plates, 17*l.*; steel angles, 16*l.* 10*s.*; steel joists, 16*l.* 10*s.*; steel rounds and squares (under 3 in. down to ½ in.), 19*l.*; steel flats (5 in. down to 1½ in.), 19*l.*; and heavy sections of steel rails, 15*l.*

Foreign Ore.—Sales of foreign ore are still few and small. Consumers continue reluctant to operate on the terms now ruling. They are fairly well placed, having rather considerable stocks, and some supplies yet to receive on contracts already made. Renewal of activity in the near future, however, is anticipated.

Coke.—Supply of coke is quite good. Deliveries to local works are on a satisfactory scale. New contracts for blast-furnace coke are being negotiated at higher prices rendered necessary by the lapse of the 5*s.* 7*d.* subsidy at the end of April, and other circumstances that add to costs.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The intervention of the Easter holidays has materially restricted operations during the past week. Large and small coals of all classes have been extremely scarce, and a number of vessels have been held up over the holidays owing to the inability of buyers to obtain cargoes. This has been the case in particular for vessels loading for neutral countries. The miners' official holidays extended over two days, but with the fine weather it is not expected that there will be anything like a general resumption of work until next week. In these circumstances outputs are certain to be much below the normal, and with the demand of inland consumers and the Allies of a pressing character it is not likely that there will be much coal available for export. An additional number of ex-German steamers have arrived to load coals for Italy, and there is an ample supply of shipping in docks to meet the requirements of exporters.

Newport.—Monmouthshire coals, both large and small, are well sold, and supplies for prompt and early shipment are extremely scarce and difficult to secure. The pressure for supplies for inland and allied consumption is heavy, and it is only in isolated cases that coals are being released for shipment to neutrals. The supply of tonnage in dock is more than sufficient to meet current requirements, and already some of the boats have been waiting over a fortnight for cargoes, and the prospects of getting supplies in the immediate future are remote, as outputs are bound to be considerably reduced by the holidays of the miners.

Strike Threat in Tin-Plate Trade.—The threatened strike of tin-plate annealers, who gave 28 days' notice to terminate contracts owing to their dissatisfaction with a recent award, is to be considered next week. The men are asking for a third man at every mill, and as there are about 500 mills in South Wales, this would mean a great addition of men. The employers cannot see their way to adopt this proposal, but are willing to allow an extra man for every four mills. The annealers' demands, if granted to the full, would mean a further increase in the cost of tin plates of from 12*s.* to 18*s.* per 100 boxes, and, in view of the serious competition of the United States, employers regard the demand of the men as a big handicap to the Welsh tin-plate trade.

Swansea Dock Workers' Strike.—The strike of general cargo workers at the Swansea Docks continues, though it is hoped that a settlement will shortly be reached. The men, it is understood, have offered to work on a flat rate which will cover all extras, and it is expected that a joint meeting will be shortly held to discuss the proposal. The men have applied for the State out-of-work pay, but the Court of Referees have refused the application, holding that the stoppage is caused by a trade dispute.

Organisation of Colliery Officials.—Much activity is shown in the direction of the formation of the Monmouthshire and South Wales Colliery Officials' Union. At a meeting of the organisation held at Cardiff yesterday, it was reported that the membership had now reached over 1,000, and that 25 branches had been established. The officials some time ago gave notice to terminate contracts, but afterwards these notices were withdrawn. The officials, however, are still very restive, and contend that in view of the responsible nature of their work they are very inadequately remunerated. They further contend that the Sankey award in relation to the miners should be also applicable to the officials. Steps are being taken to secure the co-operation of the Miners' Federation in the furtherance of the officials' programme, and it is stated that the federation are prepared to enter into a working arrangement. This is quite a new move on the part of officials who are naturally more identified with the managerial and coal-owning interests than they are with the workmen.

Colliery Clerks and the Sankey Award.—The colliery clerks in South Wales contend that they should be included in the recommendations of the Sankey report, and that they should participate in the 2*s.* a day advance in wages. The Monmouthshire and South Wales Coal Owners' Association have wired to the Coal Controller on the matter, stating that they regard the proposal sympathetically and have received a reply from the Controller urging that the advance should be given to clerks and officials excluded from the award. The colliery clerks, at a meeting on Monday, demanded the setting up of a Joint Wages Board within the next 10 days, and threaten to strike if this claim is not conceded. They also demand the union scale of wages, viz., a minimum of 4*l.* 10*s.* for chief clerks, 3*l.* for pay clerks, and 2*l.* 10*s.* for ordinary clerks, plus a war bonus of 1*l.* 14*s.*, plus the 12*s.* per week (which is the 2*s.* a day in the Sankey award).

NOTICES OF MEETINGS.

THE SURVEYORS' INSTITUTION.—Monday, April 28, when a paper, entitled "Notes on the Report of the Agricultural Policy Sub-Committee of the Reconstruction Committee," will be read by Mr. Joseph Henry Sabin, Vice-President. The chair will be taken at 5 p.m.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 29: 5.15 p.m., Ordinary Meeting, for the purpose of a Ballot of Candidates for Election; 5.30 p.m., Annual General Meeting of Corporate Members only, to receive the Report of the Council, and to elect the Council and Auditors for the ensuing year.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON): LEEDS CENTRE.—Tuesday, April 29, at 7 p.m., at the Philosophical Hall, Park Row, Leeds, a paper on "Steel Fire-boxes and Tubes, their Service, Maintenance and Repair," by Mr. Dewhurst, Locomotive Superintendent, Jamaica Railways, will be read and discussed.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Tuesday, April 29, at 6.45 p.m., the Closing General Meeting will be held in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-on-Tyne. Business: (1) Announcement of the result of the Ballot for the election of Members of Council; (2) Election of New Members of the Institution. There will immediately follow a Special Meeting for alteration in the rules, principally to create new ranks of Honorary Fellows and Fellows, and to make women eligible for the various grades for which they have qualifications. The Council have decided to hold a Summer Meeting of the Institution in Newcastle-on-Tyne, during the early part of July next; the object of the meeting being to review the progress made during the war in certain branches of engineering and shipbuilding. Provisionally, it is arranged that the meeting will take place on July 9, 10 and 11, but precise details will be issued in due course.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday evening, April 30, at 8 p.m., at the Royal Institution, Colquitt-street, the Annual General Meeting of the Session will be held.

THE ROYAL SOCIETY OF ARTS.—Wednesday afternoon, April 30, "Trueman Wood" Lecture, "Glass and Some of Its Problems," by Sir Herbert Jackson, K.B.E., F.R.S., F.I.C., F.C.S., Director of the British Scientific Instruments Research Association. The chair will be taken at 4.30 p.m. by Mr. Alan A. Campbell Swinton, F.R.S., chairman of the Council of the Society.

THE BIRMINGHAM METALLURGICAL SOCIETY AND THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Thursday, May 1, at 7.30 p.m., Joint Meeting, at the Birmingham Chamber of Commerce, New-street. Paper by Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M., President, Institute of Metals, "The Rolling Temperatures of Steels."

THE MANCHESTER METALLURGICAL SOCIETY.—Thursday, May 1, at 7.15 p.m., at the College of Technology. Dr. A. G. C. Gwyer. Subject: "Notes on the Testing of Sheet Metals."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, May 1, at 6 p.m. (light refreshments at 5.30 p.m.), Ordinary Meeting, at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Lecture on "Magnetic Storms," by Dr. C. Chree, LL.D., F.R.S.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Friday, May 2, at 7 p.m., at the College of Technology, Sackville-street, Manchester. The paper read by Mr. E. M. Gass, entitled "The Relation of Cylinder and Boiler Power to Locomotive Rating," will be discussed.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 2, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Paper, "The Mechanical Properties of Steel, with some consideration of the Question of Brittleness," by Mr. W. H. Hatfield, D.Met., of Sheffield, Associate Member.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 2, at 5.30 p.m., a discourse will be delivered by Professor J. W. Nicholson, D.Sc., F.R.S. The subject will be "Energy Distribution in Spectra." Afternoon Lectures, at 3 p.m.: Tuesday, April 29, Professor A. Keith, M.D., LL.D., F.R.S., Fullerian Professor of Physiology, Royal Institution, on "British Ethnology—The People of Wales and Ireland" (Lecture I). Thursday, May 1, Dr. H. S. Hele-Shaw, LL.D., D.Sc., F.R.S., M.Inst.C.E., on "Clutches" (Lecture I). Saturday, May 3, Professor H. S. Foxwell, F.B.A., on "Chapters in the Psychology of Industry" (Lecture I).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 2, at 7.30 p.m., at the Institution Offices. Lecturette by Captain G. B. Paterson, A.I.F., "Engineering at the Front." The Lecturette by Major H. P. Philpot, "Notched Bar Tests," has been postponed to Friday, May 16.

EARLIER HOLIDAYS.—The Railway Executive Committee write as follows: In view of the serious difficulties of the railway companies in providing engines and rolling-stock for the conveyance of traffic, it is desirable that the public should be acquainted with the problems caused by the war, and their effect on the holiday traffic of 1919. If, following the usual practice, the bulk of the holidays is taken in July and August, there will be difficulty in coping with the traffic. If, however, those who are able to do so, will take their holidays in May and June, this will do much to obviate overcrowding or discomfort.

THE FAY AUTOMATIC LATHE.

CONSTRUCTED BY THE JONES AND LAMSON MACHINE COMPANY, SPRINGFIELD, VERMONT, U.S.A.

(*For Description, see Page* 538.)

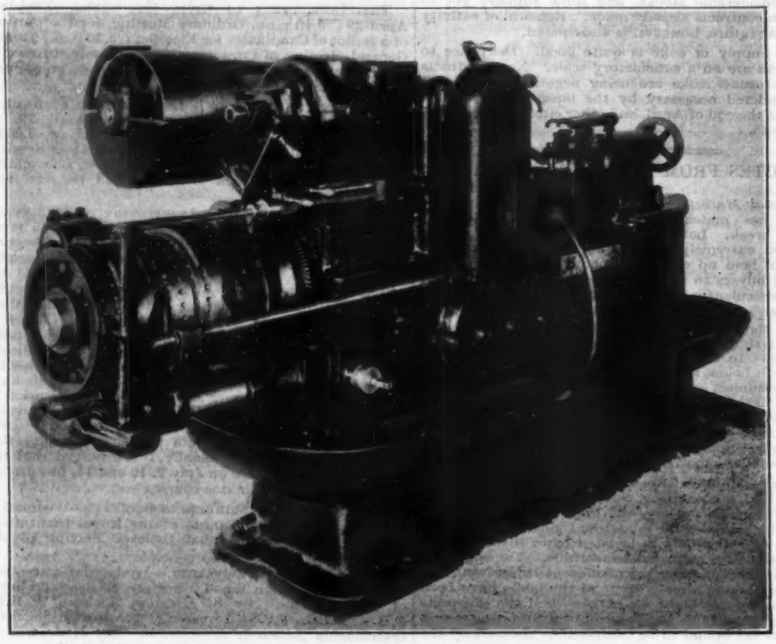


FIG. 18. CAM DRUM FOR AUTOMATIC MOTIONS.

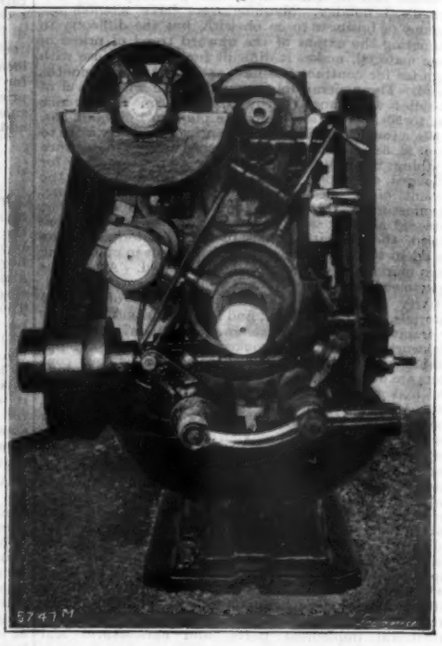


FIG. 20. CAM DRUM REMOVED TO SHOW FEED MECHANISM.

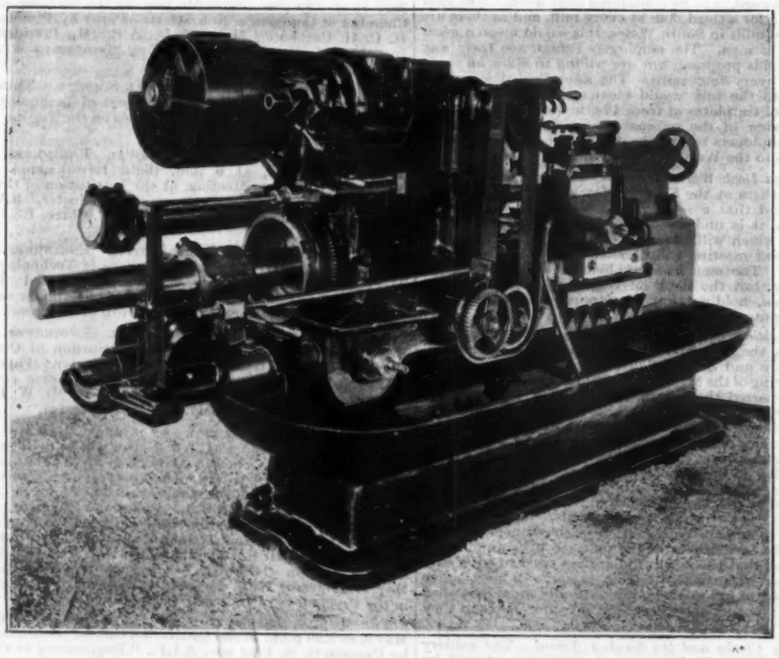


FIG. 19. CAM DRUM REMOVED TO SHOW FEED MECHANISM.

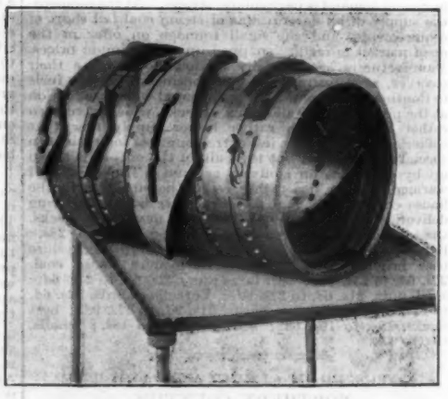


FIG. 21. CAM DRUM.

THE INSTITUTE OF METALS.—The spring and autumn meetings of the Institute of Metals will be held, respectively, in London, on May 19, and in Sheffield on September 24 and 25. At the former, Professor F. Soddy, F.R.S., will deliver the ninth annual May lecture on "Radio-Activity," for which cards of invitation may be obtained from Mr. G. Shaw Scott, M.Sc., 36, Victoria-street, S.W. 1, upon receipt of a stamped and addressed envelope. The Sheffield meeting will be the first provincial gathering of the Institute to be held since the war. The headquarters will be at the University of Sheffield. Members will be received by the Lord Mayor at the Town Hall, and there will be visits to works and other functions besides the ordinary business of the reading and discussion of metallurgical papers and reports. Those desirous of participating in the Sheffield meeting should communicate at once with Mr. Shaw Scott at the above address.

CANADIAN MISSION IN LONDON.—The Canadian Mission, which has recently been established at 1, Regent-street, S.W. 1, by the Dominion Government, was constituted by an Order of the Canadian Privy Council, in November, 1918, Mr. Lloyd Harris being appointed chairman. The objects of the Mission are, briefly, to study the tonnage position and the restrictions upon imports and exports, and to devise the means of re-establishing the traditional trade. Further, a great work of reconstruction and reorganisation must be undertaken in Europe during the next few years in order to repair the devastating effects of the war. Raw materials, &c., will be necessary for this work, and many articles required can be obtained from Canada. The Mission hopes by means of negotiations with the Governments of the countries concerned to make arrangements for the supply of such goods to the advantage of all interests involved. It is further considering how, by a system of credits, to assist the Governments in purchasing the materials. The Mission, also, is convinced that the resettlement of Europe is largely dependant on sufficient supplies of food being available and distribution being properly organised. Canada has large supplies which she is willing to place at the disposal of Europe and, moreover, by reason of the fact that she has always specialised in the manufacture of agricultural machinery and implements she is in a position to come to the assistance of the nations of Europe in their endeavours to produce supplies within their own borders. Canada seeks, above all things, to develop a larger interchange of trade with the Mother Country and, indeed, with all parts of the Empire. Canada has large markets to offer British manufacturers, for she is a large buyer. Canada, too, feels that she can supply to this country many of the materials and manufactures which formerly were bought by Britain from the Central Powers. The officers of the Mission will at all times be willing to advise persons in the United Kingdom desirous of obtaining information with regard to Canadian trade.

THE FAY AUTOMATIC LATHE.

CONSTRUCTED BY THE JONES AND LAMSON MACHINE COMPANY, SPRINGFIELD, VERMONT, U.S.A.

(*For Description, see Page* 538.)

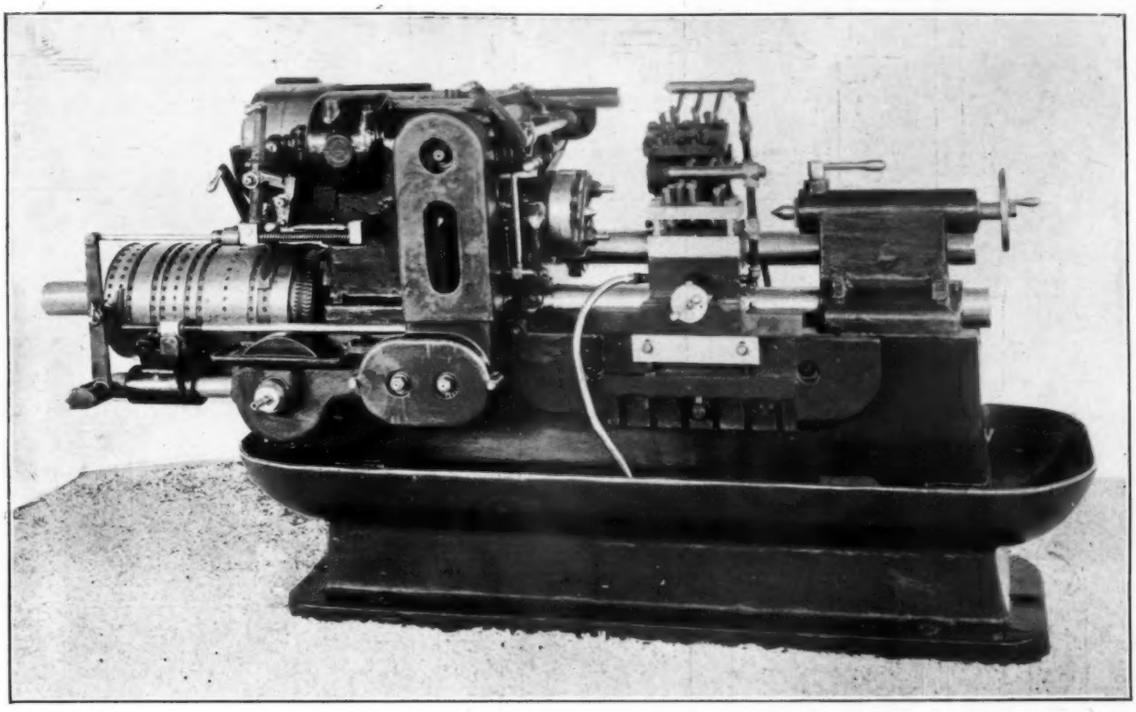


Fig. 1. The Standard Lathe.

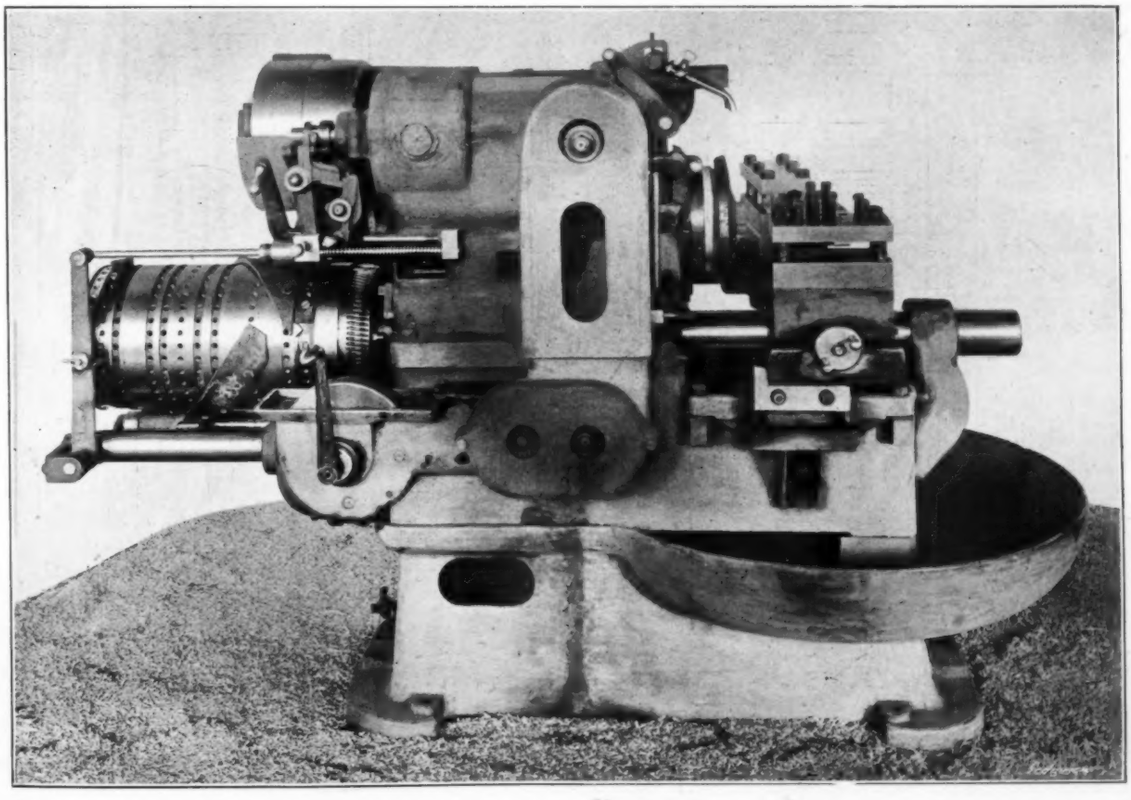


Fig. 2. The Chucking Lathe.

(*To face page* 538.)

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Fig. 4.

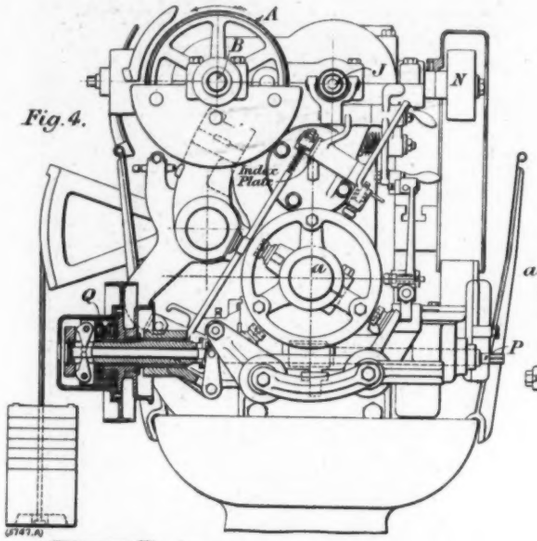


Fig. 3.

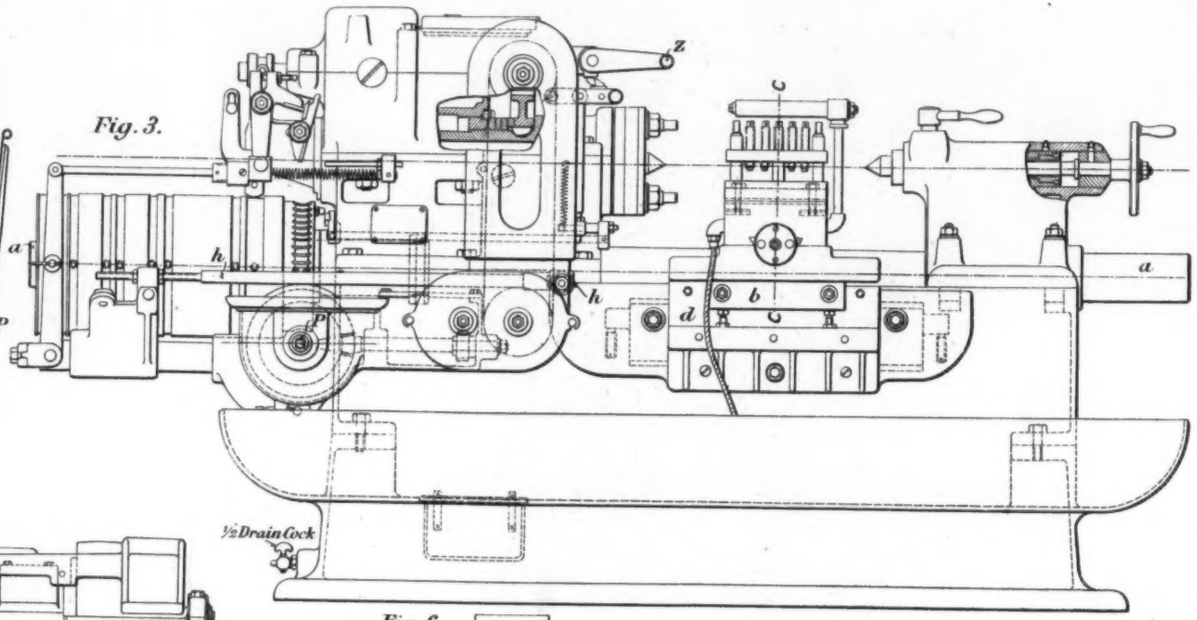
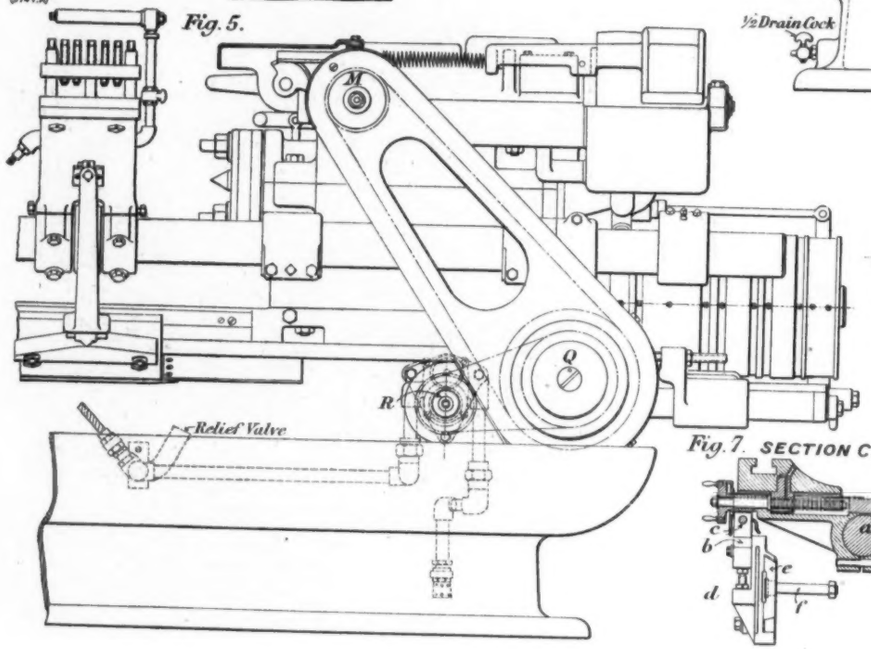


Fig. 5.



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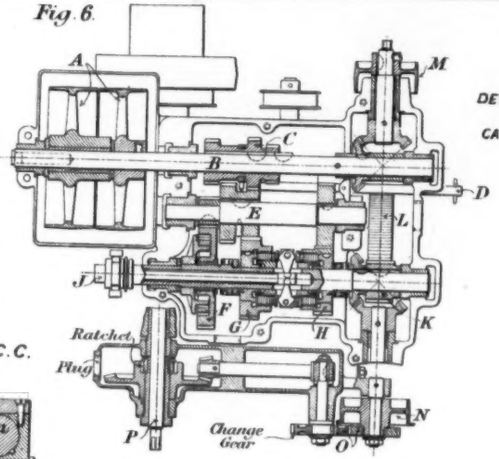


Fig. 7. SECTION C.C.

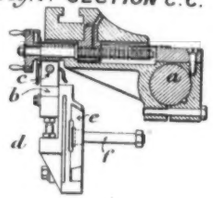
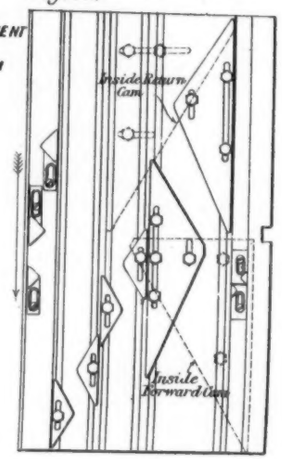


Fig. 14.



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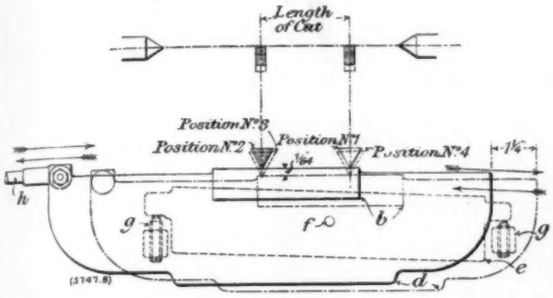

FIG. 9.

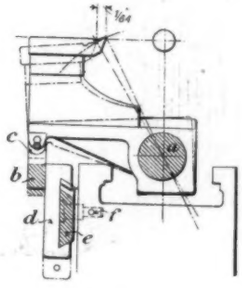

FIG. 10.

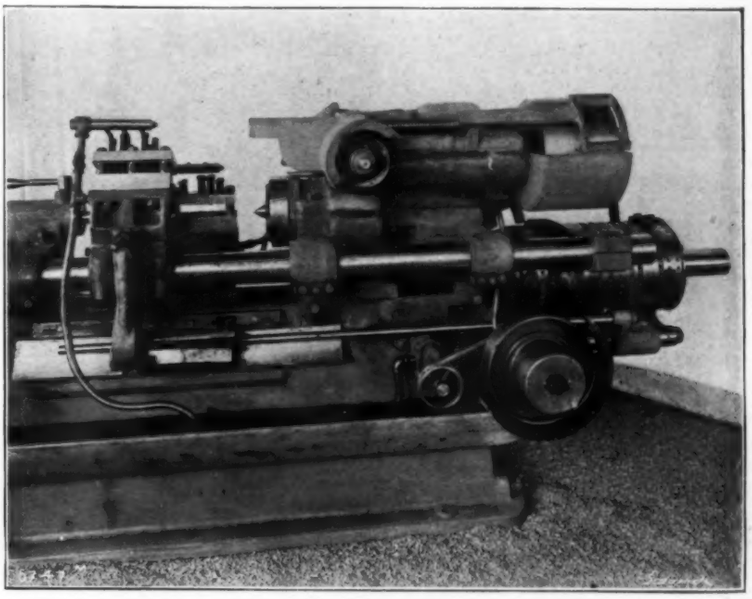

FIG. 11. BACK REST WITH DRIVING MECHANISM.

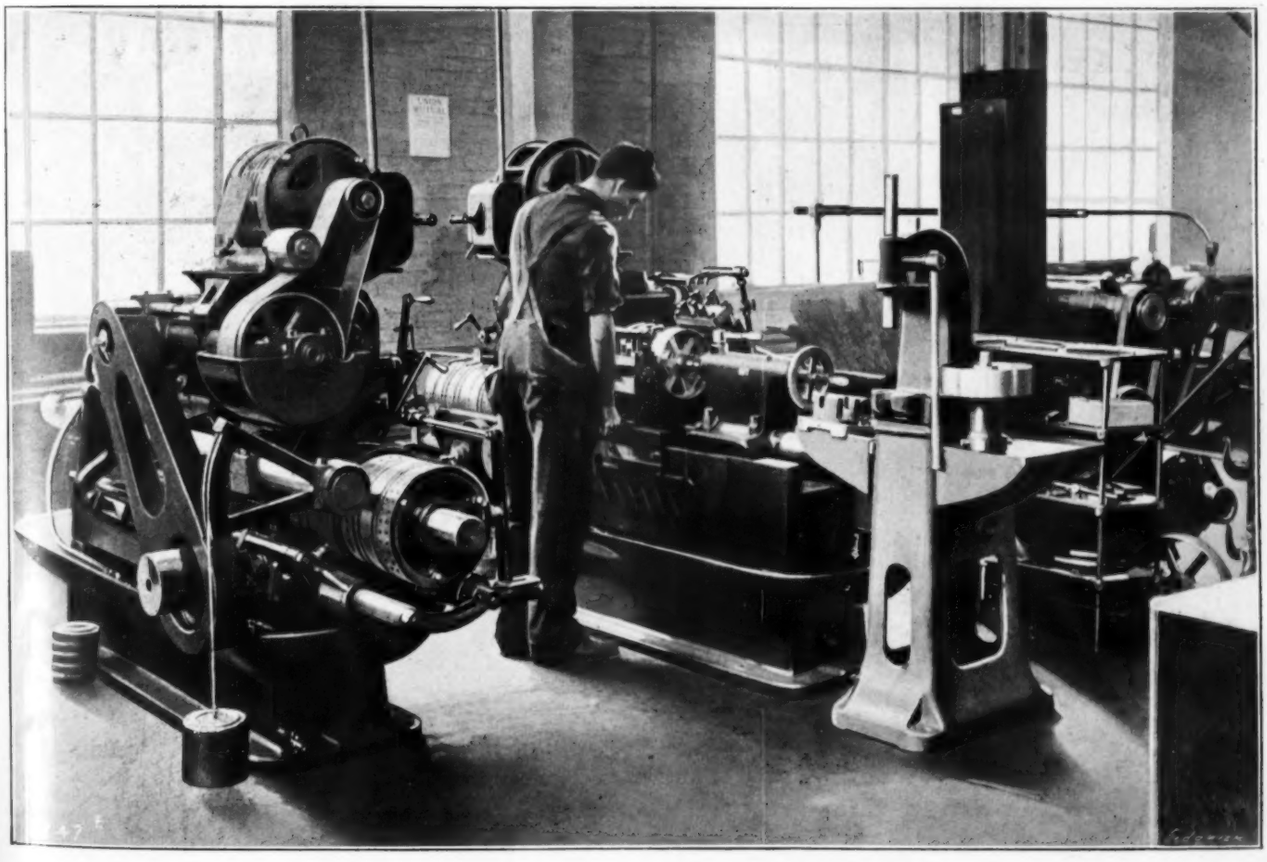

FIG. 12. LAY-OUT OF TWO STANDARD LATHES, MOTOR DRIVEN.

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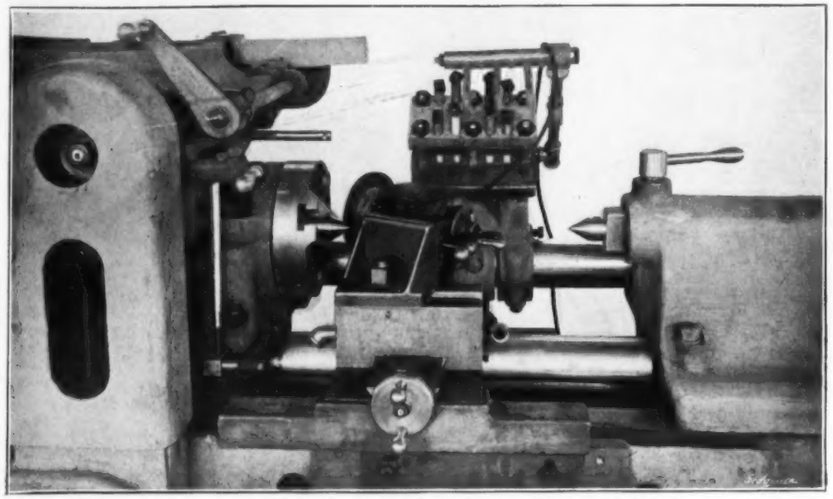

FIG. 13. TRUEING UP THE CENTRES.

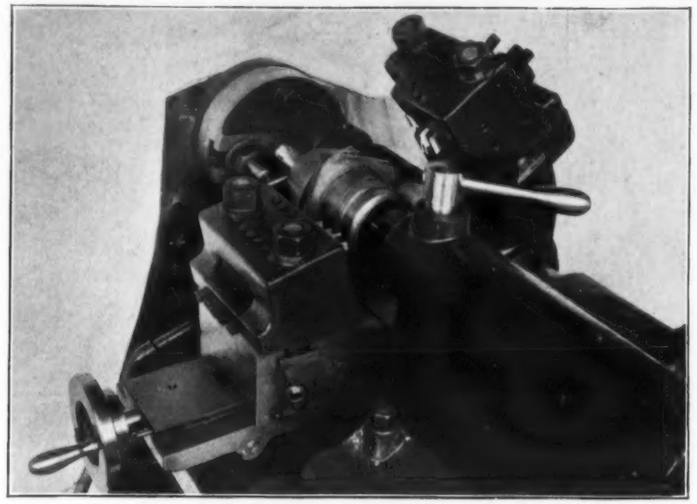

FIG. 15. MACHINING AN ENGINE CYLINDER.

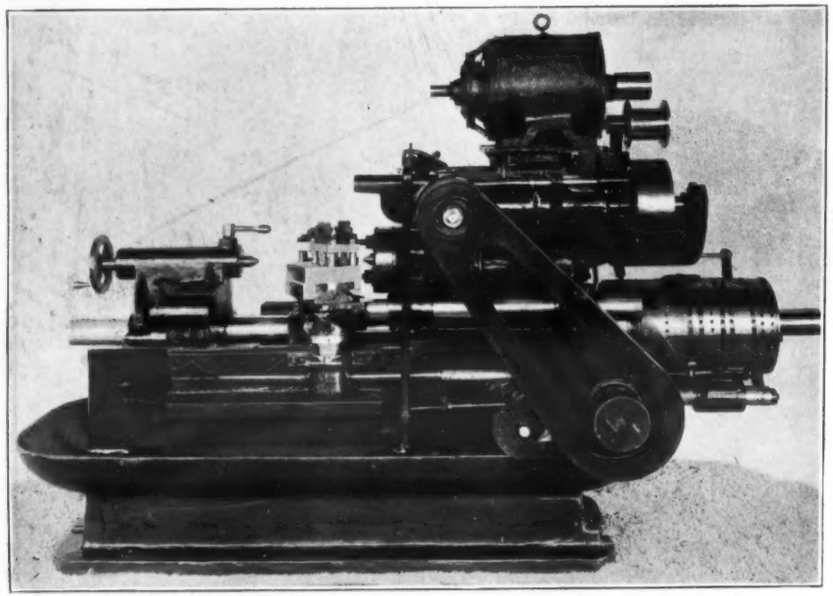

FIG. 16. COMPOUND SLIDE REST WITH ITS DRIVE.

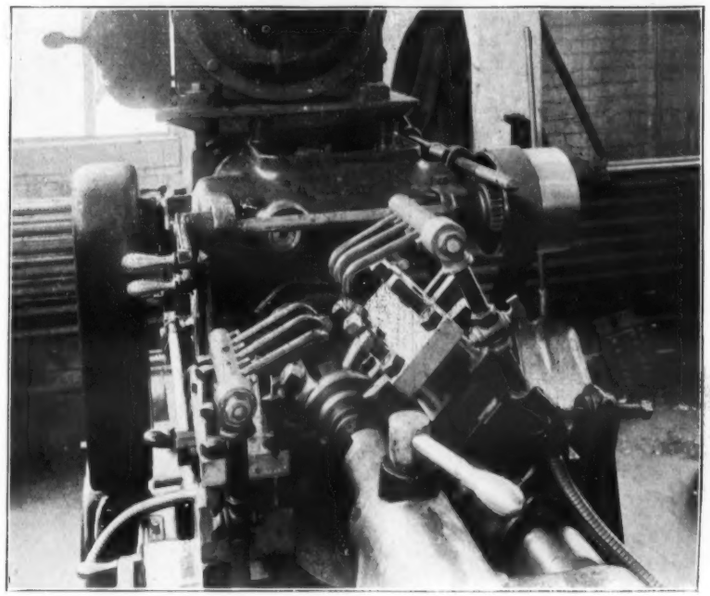

FIG. 17. MACHINING A CLUSTER GEAR.

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TELEPHONE NUMBERS—3983 and 8598 GERRARD.

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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 539.

ENGINEERING.

FRIDAY, APRIL 25, 1919.

RESEARCH OF THE HARDNESS OF METALS.

IT would be difficult to state how great a proportion of constructive engineering work and consequently of the world's employment owes its existence to the singular and unique property which steel possesses of hardening by heat treatment—but the proportion is certainly large. Civilisation and industry have, in fact, followed in the wake of our progress in the art of cutting metals. It is curious how many arts which have been handed down to us from olden times have been passed on and accepted by generation after generation without inquiry and without recorded comment. Men seemed content to accept facts as they found them, and this spirit of gentle resignation to natural events still finds its counterpart among the present-day Arabs, who will pronounce, as a sufficient explanation to cover every case, "It is the will of Allah." In the sixteenth century the age of wonder was still in its childhood, and it was satisfied to record as its opinion of the hardening of steel that "men of great reputation and learning have given it place among the greatest miracles of the world." It is one of the chief merits of our age that it is not content merely to express an opinion, but must also test its conclusion by the result of experiment, and it is this spirit of scientific inquiry which has brought about so great an expansion in the boundaries of natural knowledge.

Although the hardening of steel has been known from time immemorial, reasoned theories of this hardening action, that is, theories based on and tested by experiment, are only of modern growth, and the existing knowledge was very ably stated by Professor Carpenter at one of the Friday evening discourses before the Royal Institution recently, and reproduced on pages 340 and 386 *ante*. This lecture was all the more welcome, as a very long time has elapsed since the metallurgy of iron and steel formed the subject of these discourses, and much work has been produced in the interval.

Beginning with the consideration of the quenching process, Professor Carpenter supported the view first put forward by McCance that if the surface of a heated specimen be suddenly reduced to a lower temperature, and then kept at that temperature, the most rapid rate of quenching which is possible at the centre has been achieved, when working between these two temperature limits, and this rate cannot be increased, since it depends on the physical properties of the metal for conductivity, specific heat and density, which only vary within narrow limits. The prospects of improving tool steel through better methods of quenching are thus definitely restricted.

Theories have two uses. They explain existing facts on the basis of known causes and they suggest methods for the acquisition of new facts, and their virility may depend more on their success in the second category than in the first. Bohr's theory of the atom and Planck's quantum theory are modern examples of this class, and although the beta iron theory of hardening originally proposed by Osmond may find few supporters to-day, and the subcarbide theory of Arnold be equally neglected, there is no denying, as Professor Carpenter recognises, that "whatever may be the verdict of history on these two theories, there can be no question that each has been justified by the volume and character of the research work to which it has led." The modern theories which have been proposed are as yet too recent to state how much new work they have initiated, since they were only proposed in 1914, and war conditions since have absorbed all the world's energies.

They have much in common, since they all ascribe the hardening properties of steels to be a property of the iron present, and seek to connect it with the hardening produced in all metals by cold work. Carpenter and Edwards believed that the cold-worked condition was brought about by crystal twinning under the influence of the quenching stresses. Humfreys explained it by the incomplete change from gamma to alpha iron leaving the molecules in a disordered state, which, he postulates, would confer the same hard properties on the steel as the amorphous phase of Beilby produced by cold work. McCance showed that under the conditions of quenching, the change in the state of the carbon and the gamma-alpha change in the iron took place independently, so that the former could be entirely suppressed, while the latter was partially completed. The alpha iron produced under such conditions was in the same state as alpha iron cold-worked, though he did not state any theory as to why cold-worked metals are hard. It is interesting to note that this view of the independence of the carbon change, and the iron change has since been completely confirmed by investigators in France, who have shown that the suppression of the carbon change by sufficiently quick cooling allows the gamma-alpha change to take place during the cooling at about 250 deg. C. This new fact might be thought a point of little commercial importance, but it has already led to the development of a successful method for the prevention of distortion and cracking in large forgings which require heat treatment. The laboratory is thus ever being brought nearer to the workshop, and the time-lag between discovery and practical use is no longer measured in centuries, but in months.

In actual practice a cutting tool breaks down owing to the nose softening or tempering through the heat developed in cutting. Improvement in the life of the tool can therefore be looked for either through the prevention of the rise in temperature at the cutting edge by the use of a cooling medium—a method well known and widely practised—or by slowing down the rate of tempering at any temperature, or, what amounts to the same thing, raising the temperature at which strain hardness disappears. Phelps has pointed out in the case of gold that a very small quantity of dissolved gas may have a marked influence in retarding the loss of hardness in heating in strained material, and it seems to be a general law that impurities raise this temperature. In plain carbon steels the rate of loss in the hardness is highest at 250 deg. C. when they have been water quenched, but in a high-speed steel which has been air cooled from 1,200 deg. C. the loss of hardness does not begin until about 600 deg. This gain in stability of 350 deg. represents the advantage which a high-speed steel containing tungsten, chromium and vanadium possesses over a plain carbon steel. It gives to this type of steel the faculty of keeping hard at a dull red heat—a faculty which Taylor called the "red hardness"—and it is the essential difference which distinguishes high speed steel from other types.

In addition to the hardness produced in steel by heat treatment, there is also available for the purposes of cutting tools the natural or inherent hardness of materials, such as the diamond possesses in so supreme a degree, and this opens up a wide prospect for research and development among the alloys, and it is from this source that future cutting tool materials will most probably come. Already there has been some success in this direction, and good results have been obtained by the use of cast tools made from an alloy of cobalt, chromium and tungsten. It is not too much to hope that some element or combination of elements in steel, or some non-ferrous alloy, will be found which will gain another 100 deg. in the stability range, for such a difference would represent as great an advance over present-day high-speed steel as high-speed steel at present possesses over plain carbon steel.

In his development of the art of cutting metals Taylor considered all the possible variables and

(To face page 539.)

then varied each one separately as far as possible. He worked carefully for twenty-six years, guided only by experiment, and it was not until many years had passed that he employed a collaborator to reduce the experimental results to a basis of theoretical law. His work on this subject is the completest monument existing to the scientific method applied without intuition. It absorbed much patience and energy and cost roughly £50,000, and no one will question the immense service that was rendered to the world when the results were published. High-speed steel was one of the variables in that investigation, and the development of this alone has revolutionised the world's productivity. When it is necessary to progress along new lines it must be left to the individual, however, whether he accepts the guidance of theoretical considerations or, with a blinder faith, trusts only to the results of trial and error by experiment. It is a personal choice decided by temperament. But new discoveries based on chance observation are becoming more and more rare, and the future discoveries will be derived to an increasing extent by theoretical deduction from existing knowledge. Let us carefully scrutinise new theories, therefore, since it is from them that our inspirations for new progress will have their source.

METROLOGY.

THE British manufacturer has been lectured a great deal of late on his sluggish and unscientific methods. In particular he has been admonished that, without accurate measuring, he could not possibly maintain efficient production on profitable lines. Before the war the successful manufacturer could afford to smile at these admonitions. As long as he could, at the annual meeting, congratulate his partners and the shareholders on another prosperous year, due, they would agree, to their cautious, progressive policy, there was no need to reform their old-established methods and to adopt the new devices and tests of scientific faddists who delight in absurd accuracy. The manufacturer, who had a hard struggle, listened to the exhortations in a different mood. Instead of assisting him, he complained, when he was crushed by unfair competition from all sides, they blamed him for not doing the impossible, scrap his machinery and methods, and develop new lines in order to secure new markets. The war gave a rude shock to both these classes. It is not surprising that the shock came from the munition works. Parts that had been fairly interchangeable as long as made in one shop and assembled in different shops of the same firm, would not fit at all when sent in from works all over the country. The necessity of accurate measurements and gauges then dawned upon people who had so far little troubled about small fractions. A general demand and cry for accurate gauges arose, since half of those in use proved absolutely useless, and there were very few firms to meet that demand. The country knows how the National Physical Laboratory stepped in, and, co-operating with manufacturers and the authorities, saved the situation.

The armistice put a stop to this feverish activity, and people began to reconsider the situation. Apparently the difficulties have been overcome. Some people do not want to be bothered any more about compulsory tests and limit gauges, now that their staff is trained and normal industrial conditions are apparently being restored. The National Physical Laboratory has done its task; their projections apparatus for screw measurements have rapidly become popular in America as well as here, and excellent Johansaen gauges are now made in this country. Let the Laboratory or its metrology department be maintained as a national superior testing station and for research—on an adequate moderate scale. Others would welcome the creation of laboratories and metrology departments in the main centres of manufacture all over the country, in connection with the Universities or technical colleges, for the threefold purpose of conducting research, of teaching to measure and of working to exact gauges, and of technical testing. The former class of those inclined or, at any rate, apt to drift back into the old ways of the rule of thumb may not be numerous. The strenuous advocates of the latter view, that each technical college should have a testing department and station attached to it, may not have very general and powerful support in the country either. The long discussion on "Metrology," held by the Physical Society recently, proved unmistakably, however, that both these views have to be reckoned with, and that the latter view certainly strongly appeals to both academical and practical men. The Physical Society issues official abstracts of its proceedings, and an account of this discussion will, as usual, be published in due course. To-day we do not propose to deal with the matter in detail, but only submit a few considerations. We are not afraid of being suspected of friendship for the rule of thumb. We should probably agree with most of what was said during the discussion concerning the necessity of science in the workshop. But we should hardly go so far as the advocates of the second view quoted, and it is mainly on this aspect of the metrology discussion that we want to comment

It is only natural that the discussion centred about the National Physical Laboratory, and it was appropriately opened by the director of that institution. Sir Richard Glazebrook disclaimed the initiative of the discussion, however, which came from Dr. P. E. Shaw, of Nottingham, one of the advocates of the view that each technical college should do for its own area what the National Physical Laboratory does for the whole country. Nobody wishes to deprive the National Physical Laboratory of its leading position or to usurp its functions. Teddington would remain the central parent institution, a supervising centre. But each centre of industry is to have its own testing laboratory. The financial question was not touched upon at all, strangely enough. Before Teddington took up the testing of gauges, in the sense in which it has developed during the war, each contractor made his own gauges, when he recognised their indispensability, and that led to worse confusion. The National Physical Laboratory had first to reject some 75 per cent. or 80 per cent. of the gauges submitted; in the course of a year that figure represented the number of acceptances. There was a great deal of grumbling about the rigour of the Teddington tests; but, Sir Henry Fowler acknowledged during the discussion, he had never heard that the reports of two Teddington tests of the same piece had differed. Mr. M. F. Ryan, Director of Munition Gauges, ascribed the difficulties they had had to overcome chiefly due to the inexperience both of the designers and of the makers of the gauges. A Government department made drawings, the drawings were measured up, and the standards made according to the inexact measurements could not but be faulty; that discouraged the manufacturers and hampered the supply of correct gauges more than anything else. To overcome the lack of experience in the workshop, Mr. Sears, with Mr. Dudding and others from the Metrology Department, had to teach the men how to measure accurately. They could not continue to do that for the whole country and, therefore, Dr. Shaw and Mr. W. H. Botton, of the University of Sheffield, pleaded, we want to have the science of testing and measuring taught in our Universities and technical colleges. At Teddington the need had at once arisen of large workshops in which the laboratory could work out its own designs and also correct faulty gauges submitted. All the new testing stations would want such laboratories. To keep the teachers efficient and acquainted with the actual demands of the various industries, each laboratory would further have to be fitted up as a testing station. Mr. Sears considered it absolutely necessary that Teddington should remain the testing centre of the country, and nobody disputed that claim. Mr. Botton urged the same necessity for his own testing department at Sheffield, which has only been opened since the armistice, while Dr. Shaw has had his department working at Nottingham for more than two years. At Nottingham lace-making and textiles want all the available help of science; at Sheffield it is not only iron and steel, which are looked after to a certain extent, but also the older—and scientifically rather neglected—industries of tool- and machinery-making, for which Mr. Botton is rightly pleading. It comes down to this, that besides the departments of general engineering, of electrical engineering, chemical engineering, chemistry—not to speak of mathematics and physics—each technical college is to have a course of metrology studies, lectures, laboratory practice added to the curriculum, and, to keep the staff *au fait*, a testing station. One want was acknowledged during the discussion, that of efficient teachers. Nothing was said about two others—time and money. And all the three factors are sufficiently formidable.

When the Physical Society last autumn held its first general discussion on the teaching of physics—these discussions are a novelty to the society, the initiation of which is largely due to Dr. H. S. Allen, last year's new secretary—the teacher difficulty was not seriously discussed, though it is very real. Examination marks and the scholar label do not make the efficient teacher, and it will not be easy to procure men and women capable of imparting practical knowledge in the new branch of metrology instruction. Academical red tape holds as tight as Government office tape. The time difficulty must not be underrated either. Every professor wants adequate time for his own subject; the principal and the student may see how they find it. The money item, however, is the most serious, as usual. General and technical education, we are all agreed, must be improved, and that will involve heavy expenditure. Every industry claims, in addition to protection—which will stifle itself—a national subsidy, considering itself the key industry. The establishment of new metrology departments at colleges will be a very costly matter, especially if all old machinery is to be discarded and equipment with the most perfect machinery and apparatus is to be insisted upon, as it was during the discussion. That is, of course, to hold for the new testing stations as well, and, one may ask: Is it advisable to frighten the overburdened taxpayer with such claims? Taxes and prices are going up still, wages and salaries go up, though not by any means at uniform rates, and the large percentage of citizens who enjoy neither wages nor salaries may doubt how to make ends meet.

We are ready to grant metrology departments for the colleges. But we should move very cautiously as to the college testing stations. If research work and routine testing must be combined in the interest of the work at Teddington, it may appear inconsistent to deny the need of commercial testing to the new metrology departments of colleges. But the two cases are not really parallel. There must be tolerances, and there is something—to mention another point—in the complaint that some professors attend to their consulting practice rather than to their professorial duties. The creation of metrology departments would react beneficially on the general college training, but we entirely agree with Mr. Sears that commercial testing is not desirable for the colleges. Further, the National Physical Laboratory has attained its unique position because it is a unique national institution. It has had to face direct opposition and a great deal of passive resistance. There has also been a certain amount of official and private support, neither generous, however, until the need of the institution actually forced itself upon everybody. Will the new college testing stations secure the support of the large firms and powerful combines which have developed during the war and which command their own testing departments? Again, the growth of the National Physical Laboratory has been very gradual, almost in the nature of a repeated metamorphosis. The laboratory would not have become what it is if a devoted staff had not at all times been ready to do its best with inadequate equipments frequently to be rearranged. The advocates of the new scheme would probably do so likewise, though Dr. Shaw said that imperfect equipment damped enthusiasm. But the difficulties must not be undervalued. Even the National Physical Laboratory is not yet what it ought to be—the one authority in the country to maintain and to keep the standards. The actual primary standards are not in their custody, and Sir Richard Glazebrook spoke of the necessity of improving their methods and devices. The central institution is undergoing a reorganisation, and meanwhile the

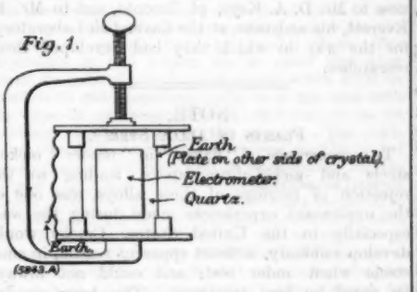
foundation of branch establishment should not be undertaken.

PIEZO-ELECTRICITY AND ITS APPLICATIONS.

NOT many probably of those who attended at the Royal Institution on Friday, April 11, to hear Sir J. J. Thomson, O.M., P.R.S., discourse on "Piezo-Electricity and its Applications," knew much more about the subject than that the late Professor Curie discovered piezo-electricity in 1883, long before his work on radioactivity, and that piezo-electricity never acquired even a modest fraction of the popularity of the latter science. Piezo-electric crystals develop electric polarities when heated. Curie discovered that they also did so when exposed to pressure; he studied the laws of piezo-electricity, and W. Voigt wrote a book on the theory of this intricate branch of electricity and crystallography, which attracted a small number of scientists, but which certainly did not promise to develop technical application. None but the initiated in Sir Joseph's audience could have known what line he would take, and his "Applications" came as a surprise.

In his introductory words Sir Joseph remarked that though electricity now dominated all science to a great extent, that electric phenomena, unlike those of light and heat, did not obtrude themselves on our attention; they were so "shy." Electricity owed its name and the science of electricity its origin to the apparently trivial peculiarity that rubbed amber attracted small light bodies. To that property the phenomena upon which he wished to discourse might likewise be traced back. In 1703, it was said, a Dutch jeweller heated tourmaline crystals on embers—it might be interesting, Sir Joseph interposed, to know what the man was searching for. He discovered that light particles stuck to the crystals when cooling. That was long before the days of our distinguishing two kinds of electricity or knowing that there were such things as electric currents. The discovery was not published; but an anonymous German pamphlet of 1707 gave an account of the observation under the title "Curious Speculations in Sleepless Nights," and from that time tourmaline became known as the electric stone or Ceylon magnet. The discovery probably went back much further, however. Pliny alluded to the mineral "carbunculus" which attracted light bodies after exposure to the sun's rays or when rubbed, and Poggendorff had suggested that Pliny's carbunculus might have been tourmaline. Sir Joseph then demonstrated the way in which these phenomena were studied. He heated tourmaline crystals in a gas oven, took them out and dusted them with the mixture of red lead and sulphur which Lichtenberg used to distinguish positive and negative electrification. The mixture was shaken and dusted upon the cooling crystals through muslin, when by friction the yellow sulphur became negatively electrified and the red lead positive; it was seen that the yellow particles adhered to the one end of the crystal which had therefore acquired a positive charge by the change of temperature, while the red particles adhered to the other end, which was therefore a negative pole. The positive pole turned into a negative pole when the temperature was rising instead of falling.

Tourmaline crystals, Sir Joseph proceeded to demonstrate, also possessed peculiar optical properties. Two crystals arranged with their optical axes parallel to one another allowed the beam of polarised light to pass, but stopped it when crossed. The pyro-electric property first demonstrated varied much in different crystals. It was associated with elongation and contraction, and Curie had made the great discovery that tension and compression had the effects of heating and cooling respectively. A squeezed tourmaline behaved electrically like a cooling crystal. To distinguish the various phenomena this electrification called forth by pressure was designated piezo-electricity; but pyro-electricity and piezo-electricity were probably of the same nature. Most tourmaline crystals formed prismatic columns terminated at the top and bottom by complex hemihedral faces; the ends were not symmetrical, as might be expected from the fact that they showed polarities. In tourmaline [complex hydrated boro-silicates of aluminium, alkali metals, magnesium and iron] the principal axis ran from top to bottom, and for experimental purposes the slabs should be cut along planes at right angles to that axis. Quartz was also useful for this purpose; in that case the slabs should be cut at right angles to one of the three axes represented, in a hexagonal cross-section of a quartz crystal, by the three diagonals. There was considerable difficulty about finding good specimens. Quartz in particular was very prone to twinning, and two twins were always doing the opposite thing so that, when tests were made on a crystal from point to point, the effects balanced one another, and there was no uniform effect over an extended area. Tourmaline was not so bad in this respect, and crystals valueless as gems might be quite serviceable; but some black crystals were fair conductors of electricity owing possibly to the impurity which made them black.



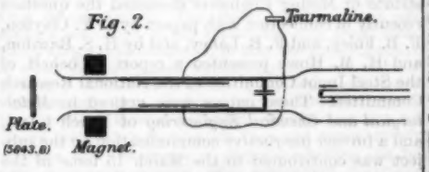


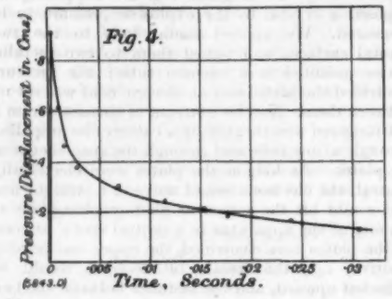
FIG. 3.

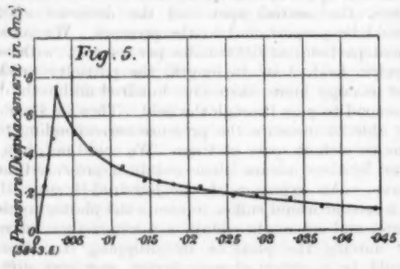
In order to demonstrate the piezo-electric effect Sir Joseph placed a piece of brass foil on a tourmaline slab and joined the foil to an electrometer; a weight was then put on the foil and pressed down by hand; the electrometer was deflected to the right. That deflection might also be due to frictional electrification; when the plate was turned upside down, however, the deflection was to the left. Quartz gave the same effect. But in another respect tourmaline and quartz differed. Tourmaline only showed polarity when pressed normally to the surface, not when the pressure was on the end faces, lateral, parallel to the surface. Quartz displayed polarity in both these cases, and the two polarities were of the opposite kinds. The difference became very important when the plates were exposed to uniform hydrostatic pressure. There quartz gave no effect, because the positive and negative electrifications neutralised one another, unless we shielded the ends off so that the pressure was unidirectional. With tourmaline the effect was observed under hydrostatic pressure, because end-pressure did not give rise to any electrification. The laws of these effects were studied by Curie, and he found that the quantity of electricity developed was just proportional to the pressure. The effect did not depend upon the thickness of the plate, and a pressure of 1 atmosphere developed in quartz $\frac{1}{4}$ electrostatic unit of electricity per square centimetre of surface; the value for tourmaline was a little smaller. But individual determinations had to be made for each crystal or plate separately; Fig. 1 illustrates the apparatus used for this purpose.

If, then, Sir Joseph continued, the quantity of electricity was directly proportional to the pressure, we could measure pressure by measuring the quantity of electricity. That might not appear worth our while. But when in the explosions in guns or engines the changes developed with extraordinary rapidity, the whole explosion only taking 1/30,000 or 1/50,000 of a second, the interpretation of mechanical pressure determinations became very doubtful, and electric methods offered decided advantages. The principle of the application of piezo-electricity which he was going to describe was explained by the diagram Fig. 2. Supposing we exposed a crystal to the explosive pressure to be measured. We applied metal foils to the two crystal surfaces and joined them to two metallic plates mounted in a vacuum tube; the pressure electrified the plates and an electric field was set up between them. Now let a stream of electrons from a hot tungsten wire (heated by a battery) be propelled through a fine tube and through the space between the plates. As long as the plates were electrically neutral, the electrons would move in a straight line and would hit the screen or photographic plate at the end of the apparatus in a central spot; as soon as the plates were electrified, the upper one turning positive, *e.g.*, the stream of electrons would be deflected upward, and the distance between the two spots, the central spot and the deflected spot, would be proportional to the pressure. We could shoot particles at 6,000 miles per second; with an electric field, 1 in. in length, the particles would not occupy more than one hundred-millionth of a second to pass through the field. Thus we should be able to measure the pressure corresponding to this very short space of time. We could not, however, by these means alone obtain a pressure-time curve. An exposure of one hundred-thousandth of a second would suffice to excite the photographic plate, and we might obtain a pressure-time curve by moving the plate or by dropping it. That would be a rather clumsy device, and very difficult, moreover, to work in a vacuum. It would be easier to move the stream of negative particles which could be deflected by magnetic force. When we placed an independent magnetic field beyond the electric field, there would be superposed on the deflections, say in the horizontal direction, by the electric force, a deflection in the vertical by the magnetic force. If we used a rapidly alternating magnetic field, the spot formed by the cathode rays would move up and down in a vertical line, if there was no pressure on the crystal. When the crystal was under pressure, the spot would undergo a horizontal deflection and would travel along a curve, giving a pressure-time curve, as indicated in Fig. 3.

In this reproduction of a photograph some curves can be seen above a horizontal band of light which itself is made up of a series of crowded zig-zag lines. The spot marking the moment of explosion, Sir Joseph explained, was in the left lower corner of the diagram; the pressure rose rapidly at first to a maximum and then fell off gradually, the spot describing a series of zig-zags; the reversals, first on the right-hand side, then on the left, and again on the right, &c., were due to the reversals of the magnetic field. In interpretating the curves one important factor had to be borne in mind. The vertical speed of the spot was not uniform, but varied harmonically like a pendulum oscillation, and equal vertical intervals did not correspond to equal intervals of time. The two intervals were, however, connected by a simple relation, and a time-pressure curve could easily be obtained from the photograph; we had to analyse the curves. Fig. 4 (like Fig. 3) represents the explosion, in an airtight vessel of brass, of hydrogen and oxygen in the proportions of electrolytic gas, 2 volumes of hydrogen to 1 volume of oxygen. The initial gas pressure was 1 atmosphere, 76 cm. of mercury, the total gas volume was 765 cub. cm.; the ordinates marked the displacements of the central spot in fractions of a centimetre, the abscissæ measured the time in fractions of a second; each square of the diagram corresponded to one two-thousandth of a second. Fig. 4 showed

that the maximum pressure was reached within a very small period, one sixteen-thousandth of a second in fact, and then fell off almost in accordance with an exponential law. When a trace of air was added to the gases, at slightly reduced pressure, the rise was slower and the maximum displacement was only 0·8 cm. (not 0·9 cm. as in Fig. 4); in the presence of a considerable proportion of air the rise to the maximum—as shown in Fig. 5—took one four-hundredth of a second, and the maximum displacement of 0·8 cm. was barely reached; a displacement of 1 cm. was equal to a pressure of 220 lb. per square inch. In these experiments an Evershed-Vignoles constant potential high-tension dynamo was used for exciting the cathode rays. The





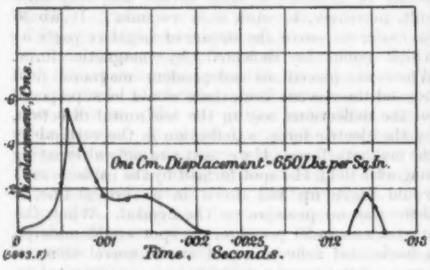


FIG. 6.

magnetic field was produced by an alternator giving 30 alternations per second; to open out the time-scale further the number of alternations might be increased many times.

By the aid of these indicator diagrams new light might be thrown on explosion phenomena, important industrially as well as scientifically. We wanted further information on the powers and time-constants of high explosives, and on the explosive phenomena in guns and in internal-combustion engines, also the effects of different kinds of petrol, of mixtures with air and other gases in various proportions, and of the sparks of the magnetos. We also needed much more information than we possessed about the explosions of different gases, such as hydrogen and oxygen, hydrogen and chlorine, &c. We could, by the aid of the piezo-electric method further observe the actual propagation of an explosive wave through tubes by putting one crystal in the one part of a tube and a second crystal in the other. In the same way we might also investigate the propagation of an explosive wave through a thickness of a solid, to the upper and lower surfaces of which we attached crystals. The last slide, Fig. 6, which Sir Joseph exhibited, proved that these things were not merely in the air. The diagram illustrated, he explained, the explosion of a charge of guncotton in sea water. The first curve, on the left, marked the direct explosion pressure; what the hump in the descending branch of the curve indicated Sir Joseph could not say; the second, less high curve, marked the pressure produced by the reflection of the wave from the bottom of the sea. It would be seen that the scale of this diagram was much more open than that of Figs. 4 and 5, and considering that circumstance, the absence of wriggles was noteworthy; a displacement of 1 cm. marked a pressure of 650 lb. per square inch. Knowing the distances involved the actual rates of propagation could be deduced.

Concluding, Sir J. J. Thomson remarked he hoped that the method described would be useful in many directions, and that the supply of tourmaline necessary for the continuation of these researches would not fail. Cane sugar might answer as a substitute for tourmaine, but it was too brittle; quartz was mechanically stronger than either of these materials. In his final words Sir Joseph expressed his indebtedness to Mr. D. A. Keys, of Toronto, and to Mr. E. Everett, his assistant at the Cavendish Laboratory, for the way in which they had developed these researches.

NOTE.

FLAKES IN ALLOY STEELS.

THE occurrence of "flakes" in "tender" nickel-steels and nickel-chrome-steels, leading to the rejection of forgings of these alloys, was one of the unpleasant experiences made during the war, especially in the United States. Cracks would develop suddenly, without apparent reason, in such steels when under test, and could not always be cured by heat treatment. The American Institute of Mining Engineers discussed the question recently in connection with papers by C. Y. Clayton, F. B. Foley, and F. B. Laney, and by H. S. Rawdon, and H. M. Howe presented a report on behalf of the Steel Ingot Committee of the National Research Committee. These papers were noticed in *Metallurgical and Chemical Engineering* of March 1 last, and a further instructive communication on the subject was contributed to the March 15 issue of the same journal by Frederico Giolotti, the Italian metallurgist, who was in New York at the time. The flakes, also known as snow-flakes, scabs, goose eggs, silver streaks, commonly appear as bright streaks, sometimes greenish in the central portion, in alloy steels which show weakness when worked. The defect is brought out in the macrostructure by etching; radiographs show white lines; micrographs indicate lack of grain refinement. The flakes or streaks are supposed to be cracks in the steel itself; they are not found in steel which welds readily, but are troublesome in nickel-steels which do not weld. Clayton and his collaborators consider that there is always evidence of overheating in flaky steel, and they adduce a good deal of experimental evidence favouring his view; the flakes, they say, pass through the ferrite existing between sorbitic grains, and also through the grains themselves. Rawdon believes that the flakes represent original crystal faces which formed during the solidification of the inhomogeneous alloy steel; the rupture would take place already in the ingot owing to the different expansion coefficients of the metals and alloys. Howe inclines to the latter view. Flakes, he points out, also appear in alloy steel which has not been heated above 900 deg. C., and are not characteristic of the zones which were hottest in the ingot. They vanish in some steels, as the nickel percentage is reduced, he admits, whilst they increase in alloy steel which has been killed in the furnace. Tender steel should hence be humoured and so cast that excessive cooling be avoided, using round moulds, stripping as soon as the walls are strong and cooling by burying in ashes. This treatment would tend to favour dendritic structure, but it would lessen the flaking. In their *résumé* Howe and Rawdon agree that flakes originate in the ingots of tender alloys as intercrystalline shrinkage cracks and are probably intensified by inclusions of segregations. Giolotti would accept this conclusion; he would say that the flakes originate in tender alloys as intercrystalline cracks, but he does not believe that they are formed in the ingot. He remarks that the Ansaldo Company, with which he is connected, made 10,000 guns for the Italian Army, and had no rejection on account of flakes, though they were troubled with them. His chief point is: to prevent flaking, keep not only sulphur and phosphorus as low as possible, but avoid all iron oxide, do not use rusty turnings or borings, and fuse in a reducing atmosphere under a thin covering of silica slag. He adds the ferrochrome 20 minutes before pouring (hardly any chrome should in good practice go into the slag) and pours hot and cools in the air—contrary to Howe; he has not observed any preferential directions of the flakes in moulds of various shapes (Howe). He ascribes the trouble to the diffusion of emulsified, microscopically undetectable iron oxide through the metal. That non-metallic inclusions are surrounded by decarbonised zones he explains by the presence of both CO and CO_2 in the steel (dissolved, not in cavities); the equilibrium: $3Fe + 2CO \rightleftarrows Fe_3C + CO_2$ is shifted to the left by an oxidising slag so that a zone of decarbonised iron is produced, supersaturated with CO. There is no internal crack, however, until the material is strained above the elastic limit.

ELECTRIC PLANT EXTENSIONS AT ILFORD.—The electricity supply of Ilford, Essex, which is in the hands of the District Council, is on the continuous-current system. The extension of the district of supply, however, together with the increasing demand from outlying areas and the building of a large Government factory at Chadwell Heath, have necessitated the introduction of high-tension transmission to the latter district. This has been done by installing an inverted rotary-converter and step-up transformer in the power station with an equivalent step-down and re-conversion plant in a sub-station. The plant, which has been supplied by the General Electric Company, Limited, of 67, Queen Victoria-street, London, E.C. 4, and Witton, Birmingham, consists of 280-kw. rotary-converter and transformer in the power house converting from 480 volts to 520 volts direct current to 6,660 volts, three-phase at 50 periods, with a similar inverted plant in the sub-station. The power-station converter starts up from the direct-current side, while that in the sub-station is started from the alternating-current side by means of a motor. Ironclad switch panels for the high-tension control are provided in both stations. Orders for further plant extensions have now been received by the General Electric Company, consisting of a 2,000-kw. Fraser and Chalmers' turbo-alternator, a 1,000-kw. Witton rotary converter with transformer, a five-panel truck-type high-tension switchboard and the necessary low-tension switchgear. Both the extensions are to the instructions of Mr. A. H. Shaw, M.I.E.E., M.I.Mech.E., the engineer to the council.

IMPORT RESTRICTIONS.—The President of the Board of Trade, after duly considering the recommendations of the Consultative Council on Imports, has given directions according to which the restrictions on the importation of the following articles of interest to our readers are to be removed: Belt hooks for machinery and sewing machines, bolts and nuts, wood screws, chimes and whistles, cycle nipples, Edison cells (and component parts) for electrically-propelled vehicles, enamelled steel tanks with glass linings, Heddle steel strip, iron-hook strip, tube strip and ground flat steel stock, machine tools and parts, tools and appliances. Also the following: abrasive wheels, adjustable clamps, anvils, auger bits, bench drills, bolt clippers, boring heads, callipers, carpenters' tools, chasers, chucks, coopers' tools, cutting nippers, dial gauges, dies and die-stocks, die-heads, drills, drill presses, drill sleeves and sockets, emery-wheel dressers, engineers' hammers, expanding mandrels, expansion bits, farriers' tools, furniture and dovetail bits, gauges, glass cutters, hacksaw blades, hand and breast drills, hand grinders, hand screwing machines, hide hammers, iron hammer heads, joiners' tools, lathe carriers, lathe dogs, lead hammers, machine vices, masons' tools, measuring tapes and rules (except wooden rules) and including verniers, micrometers, milling cutters, mitre blocks and scrapers for metal, mitre boxes, nail pullers, pipe cutters, pipe vices, pipe wrenches, pliers, polishing heads, punches, reamers, saws—band, circular, cross-cut, kitchen, and others, screwing tackle (*i.e.*, chasers, dies and stocks, taps and thread-milling cutters), shipwrights' tools, slide rules of metal, smiths' tools, spanners, swage shapers, tailors' shears and trimmers (6 in. or more in length), tapping attachments, taps, tap wrenches, tool holders, trench struts, tube expanders, upholsterers' or household hammers, welt ploughs (Deacon's), wood boring bits, wood scrapers. Further: Treadle lathes of 3-in. centres and over, wire hooks (other than coat and hat hooks), wood-working machinery and parts thereof, time recorders. The importation of the following articles is to be or remain prohibited: Wood rules, with the exception of 12-in. school rules (the latter to be admitted by licence when necessary), slide rules other than metal, cycles other than motor cycles, portable platform weighing machines. The importation of the following articles is to be restricted as shown: Ball bearings, roller bearings, ball retainers, ball bearings, bolts and steel balls, are to be allowed to be imported only under limited licences. Applications for special licences should be made as usual to the Department of Import Restrictions, 22, Carlisle Place, London, S.W. 1.

THE U.S. ELECTRICALLY-PROPELLED BATTLESHIP "NEW MEXICO."

By Commander S. M. ROBINSON, U.S. Navy.

THE completion of the New Mexico's trials marked the successful end of a campaign that was begun more than ten years ago by Mr. W. L. R. Emmet, of the General Electric Company. At that time, Mr. Emmet, in his advocacy of electric propulsion, was in the position of an apostle with a small following, but in the Bureau of Steam Engineering of the Navy Department he found an organisation that was progressive enough to undertake the development of a system that offered such great advantages, and so he was able to secure a contract with the Navy Department for the machinery of the collier Jupiter, and thus the experiment of electric propulsion was begun. It was successful from the start, and after a year's trial, Rear-Admiral R. S. Griffin, the chief of the Bureau of Steam Engineering, shouldered the responsibility of putting it into capital ships, the New Mexico being the first.

Before proceeding to a description of the New Mexico and her machinery, the advantages of electric drive will be briefly touched upon. Inasmuch as the machinery plant of every type of ship is a complete problem of itself, the comparison of electric drive and other types of propulsion will be confined to that type of ship for which the United States Navy has adopted it—the capital ship. Owing to the large horse-powers that are used in this type of ship, the choice of a method of propulsion is limited to direct-connected turbines, geared turbines, and electric propulsion, so that comparison will be made between these three.

The first of these suffers in all points as compared with the latter two, and therefore may be discarded at once, provided either of the latter two methods are sufficiently reliable to make them satisfactory for naval purposes; therefore, the comparison may be further restricted to geared turbines and electric drive.

The comparison between the two types of installation should be made in regard to the following points:—

1. Reliability.
2. Necessary weight and space.
3. Steam consumption.
4. Flexibility as regards installation.

Of course, no type of machinery can be given any consideration which is not absolutely satisfactory in regard to the first point—reliability. It is believed that the experience of the Navy Department with electric propulsion on the Jupiter has demonstrated its reliability beyond any reasonable doubt. That ship has been in commission over five years, and has been in continuous service with practically no electrical troubles. The trials of the New Mexico, just completed, indicate that she should duplicate the Jupiter in this respect. There are several reasons why electric propelling equipment should be more reliable than other types of machinery. The weakest member of electric propelling machinery is in the same place that it is with other types of propulsion—that is to say, in the steam turbine itself. However, owing to the fact that this turbine has no backing turbine on it, and therefore always runs in the same direction, it should be much less liable to damage than those turbines which are directly geared or connected to the propelling shafts. Also, it should be much less liable to damage from mis-alignment. In many cases with direct-connected or geared turbines, the wrecking of one turbine will put two shafts out of commission; with electric machinery this is never the case, as each shaft can be entirely isolated from the others by opening the disconnecting switch of the motor on that shaft. Also, in case of damage to a turbine, with the straight steam drive, the work on the remaining shafts is very much increased owing to the drag of the idle propellers; with the electric drive, failure of a turbine does not in any manner affect the method of propulsion as all screws will still be in use. This is quite an important point—not only because of the added resistance of the dragging screw, which may be as high as 15 per cent. of the total effective horse-power required to drive the ship, but also because the manœuvring qualities of the ship are seriously affected. This is especially true if the damage to the turbine is such that its shaft cannot be allowed to revolve; in this case, the maximum speed of the ship will be very low, as it will not be possible to lock the damaged shaft against high speeds of the ship. Another less important advantage of the electric propulsion ship is its flexibility of operation, which allows the operating engineer quickly to shift from one turbine to the other; this advantage is brought out most strongly in the case of a ship entering or leaving harbour where one of the main condensers may be temporarily plugged with mud or other foreign matter, requiring a temporary shut-down of that turbine.

In regard to the second point—the question of weight and space—there is little to choose between the electric drive and the geared drive, but both are very superior to the direct-connected turbine in this respect. In the case of the New Mexico there was a saving of over 200 tons in machinery weights as compared with her sister ships, which were equipped with direct-drive turbines and geared cruising turbines. It is probable that the geared drive has some advantage over the electric drive in this respect, but the difference is not great enough to be of much importance.

In regard to the third point, the steam economy, the geared drive will have a maximum advantage of 5 per cent. at full power over the electric drive; as the speed is lowered, this advantage very quickly disappears, and at most of the operating speeds of the ship the electric drive will be better in this respect; at the cruising speeds of 15 knots and below, the advantage of the electric drive in this respect will be very marked, indeed. Of course, this advantage of electric drive at the lower speeds can be offset by installing a separate set of geared turbines for cruising purposes, but in this case any advantage of the geared drive as regards weight will then disappear and the operation of the machinery will become very much more complicated.

In discussing the fourth point—installation—I will touch upon the main and compelling reason for the adoption of electric drive for capital ships. The advantages in this respect are so great that they cannot be ignored. Any prime mover which must be attached to the propelling shaft, as is the case with any type of machinery except electrical, is at an enormous disadvantage in this respect. The main turbo-generators for electric propulsion may be placed in any part of the ship that is most suited for the purpose; they may be placed in compartments forward of each other on the centre line; they may be placed at any desired height above the base line; and, in fact, there is practically no limit to the variety of the arrangement. The result of this flexibility is that a ship can be designed to give far more adequate protection to the ship and machinery against damage by torpedoes and gunfire than is the case with any other type of machinery. The main motors, which are directly connected to the shafts, are very small compared with a geared turbine, so that the compartments in which they are placed will be very small and will not involve a menace to the ship if flooded; and these compartments are, of necessity, vulnerable because they must be located outboard. The motors can be placed very much further aft than can steam-driven turbines, and the length of propeller shafting can be very materially reduced, with consequent reduction of liability to derangement of the shaft itself on account of injury to the ship, and also reduction of danger to the ship itself on account of the shafting not having to pierce a number of watertight bulkheads. The most important auxiliaries can be concentrated in the machinery compartments located on the centre line of the ship where they can be best protected, instead of being scattered around the ship in various vulnerable turbine rooms, as in the case of gear-driven installations. Also, from an engineering point of view, electric drive gives an ideal arrangement as it is possible to group the boilers around the engines in such a way as to give the minimum length of steam and other piping, as well as a reduction in the diameter of the pipes and in complication of their arrangement. This is of the greatest importance in the case of battle cruisers, where the problem of getting steam from the boilers to the engines becomes a serious matter if it is attempted to make the orthodox arrangement of fire rooms and engine rooms with all the boilers forward of the machinery space and all of the steam pipes united before they are brought to the turbines. The maximum size of steam piping, except for a short section at each turbine, is very little greater on the battle cruiser, as laid out with electric drive, than it was on former battleships, and the total length of main steam piping is not much greater on the battle cruisers than it is on some of the former battleships.

The New Mexico is one of three sister battleships, the other two being the Mississippi and the Idaho. The first of these is equipped with direct-connected Curtis turbines and the later with direct-connected Parsons turbines, and both ships have geared cruising turbines. The following table gives the dimensions:—

Length overall	624 ft.
Length on load water-level ...	600 ft.
Breadth, extreme	97 ft. 4½ in.
Draught	30 ft.
Displacement	32,000 tons
Designed speed	21 knots.

The main propelling machinery of the New Mexico consists of two alternating-current turbo-generators, four induction motors, two 300-kw. direct-current exciters, two motor generator boosters, main switchboard, exciter switchboard, ventilating blowers for the main motors, and the necessary wire and cable. The weight of the above machinery is approximately 500 tons. The main generators are two-pole, quarter-phase, having a maximum capacity of about 12,500 kw. Each generator is provided with a disconnecting switch, which is double-throw; in one position of this switch the windings of the generator are arranged in the series or square connection, and in the other position of the switch the generator windings are arranged in parallel or diametral connection. The first position is used when one generator is operating two motors, and under this condition the maximum voltage of the generator will be 4,242 volts. The second condition is when one generator is operating four motors and under this condition the maximum voltage will be 3,000 volts. This arrangement enables the generator to utilise to the best advantage the doubled current capacity of the motor circuit when using four motors, and improves the overall efficiency of transmission. With this exception, the generators differ very little from the ordinary commercial type of alternator, except that special care was taken in the treatment of the stator coils, particularly the projecting end windings, in order to make the insulation moisture-proof. The generator field was also designed with a liberal margin in regard to heating, to be able to take care of the overexcited condition that arises when manœuvring.

The turbine differs very little in its construction from the ordinary commercial turbine used for driving alternators; there are a few points of difference, however. The casing is divided at the low-pressure end through a plane at right angles to the axis so that it is possible to lift that portion of the casing which covers the blading without disturbing the exhaust connection to the condenser overhead. The governor differs from the ordinary type of governor in that it has a movable fulcrum which makes it possible quickly to change the speed which the governor will hold on the turbine. All speed changes are accomplished by shifting this fulcrum. The turbine has two openings in its casing for the admission of exhaust steam from the exciters or the auxiliary exhaust line, and there is an automatic valve in this exhaust line which is operated by the governor-controlling mechanism. When the governor shuts all main steam off the turbine, further movement will open this automatic valve and by-pass the auxiliary exhaust to the main condenser. The turbine is provided with an overspeed governor which closes the main throttle and also closes automatic trip valves in the lines which supply auxiliary exhaust steam to the fifth and eighth stages of the main turbine, thus shutting off all sources of supply of steam to the main turbine. The control mechanism of the governor is extended to the centre engine-room by means of bell-cranks and levers.

The main motors are designed to give about 29,000 h.p. at 167 revolutions, which corresponds to a speed of 21 knots of the ship. The motor stator windings are arranged to provide for pole-changing and are provided with pole-changing switches which give 24 poles on the stator when in one position and 36 poles when in the other position. The motor stator is provided with only one winding, and the pole-changing is accomplished by changing the arrangement of this one winding. The motors differ more from previous designs than any other part of the machinery. It is believed that these are the first motors of this type constructed, other than experimental ones. They are of the double squirrel-cage type, with two independent sets of windings in two slots which are separated by a deep air gap of narrow section. Extreme care has been taken in arranging the short-circuiting rings to provide amply for the very great expansion which takes place in these motors when manœuvring, due to the large rushes of current. The inner squirrel cage, or lower bar in the slot, is of low resistance, while the outer squirrel cage is of high resistance. In operating under normal conditions with the motor running at practically the synchronous speed of the generator, the two squirrel cages act like parallel circuits. At low frequencies of the rotor, such as obtain when the motor is running at practically the synchronous speed of the generator, the reactance of the rotor is very small, whereas with large slips, such as obtain when reversing, the reactance is very much greater. The physical explanation of what takes place is that during ordinary running the rotor flux circles both squirrel cages, but when the frequency of the rotor becomes high, the flux is forced across the narrow air gap, practically short-circuiting the inner squirrel cage, and thus giving the effect of a squirrel cage of high resistance and providing the necessary torque for reversal. The torque curve of the motor will be a resultant of the two squirrel cages. The torque required for reversal is very large owing to the peculiar shape of the torque curve of the propeller. In fact, the shape of the propeller torque curve during reversal is the deciding one in the design of induction motors for this work, and makes the problem very much more difficult than would be the case if the torque dropped in a uniform manner all the way down. It is necessary to slow the turbine down during reversal; otherwise, the motor could never pull into synchronism with the generator as the torque required to drive the motor astern at the same speed as when going ahead is several times the latter.

The control gear and switches for the propelling

equipment are mounted on main and exciter switchboards. The exciter switchboard contains the main generator field switch and the switching necessary for the various auxiliaries that are motor driven; the rest of the equipment is contained in the main switchboard, except the generator disconnecting switches, which are mounted on the engine-room bulkheads, just outboard of the main switchboard on each side of the centre engine-room. On the upper part of the switching structure are mounted the motor-disconnecting switches which are of the knife-blade type. On the inside of the cell structure is mounted the bus-tie switch which connects the two sides of the ship, making it possible to run all four motors from either generator, this is also a knife-blade switch. The pole-changing and reversing switches are of the oil type and are mounted inside the cell structure of the board. The pole-changing switches are of the laminated brush type, and the 24-pole and 36-pole switches are mounted in the same oil tank; contact is made on one side for the 24-pole connection and on the other for the 36-pole connection. The same is true of the reversing switches which make contact on one side for the "ahead" direction and on the other for the "astern" direction. Reversing switches are three-pole, the fourth wire being carried straight through to the motors; it is necessary to open one wire of the second phase when the switch is in the off position, as otherwise, the motor would continue to run as a single-phase motor after having been started. Reversal is accomplished merely by crossing the two leads of one of the phases. Only one lever is used for operating the reversing switches of one pair of motors and the same is true of the pole-changing switches. The speed lever is mounted on the front of the switchboard and is connected by rods and bell-cranks to the governor mechanism already described. The steam-limit lever is mounted on the switchboard directly underneath the speed lever, and connects to the governor mechanism by means of rods and bell-cranks. This steam-limit lever, when set at any given position, limits the amount of steam that the turbine can take by interposing a stop in the way of the governor. This steam-limit lever is necessary on account of the big change in power that takes place when the ship is turning. The turbine, being at all times under control of a governor, will attempt to run at a constant speed regardless of the power used and in turning with full rudder at full speed of the ship, the power required for this purpose is far in excess of what the generator is capable of giving, so that if a limit were not set on the amount of steam that the turbine can use at any given speed, the result would be that the generator would be unable to hold up its voltage when the excess power is thrown on it, and the motors would drop out of step. The field lever is mounted alongside the speed lever, and operates both the solenoid for closing the main field switch and the rheostat of the booster which controls the strength of the main field. The main field switch is solenoid operated and is mounted on the exciter switchboard.

The booster is a motor generator set, the motor end of which is a constant-speed motor; the field current for the main generator passes in series through the generator end of the booster. The field lever on the switchboard varies the field of the booster generator, and hence its voltage, thus regulating the voltage imposed on the slip rings of the field of the main generator. The field of the booster generator is arranged so that in the mid-position of the field lever it has no field at all; in full throw of the field lever in one direction, the generator boosts the 300-kw. generator voltage about 60 volts, and in the other position of the field lever it bucks it about 60 volts. The booster was used for varying the field of the main generator instead of using a generating set for this, because it was desired to have the exciting sets the same size and construction as the ship's power and lighting sets, which were 300 kw., but the power used for excitation was only about 55 kw., so it was decided to utilise the remainder of the power of the 300-kw. sets for running the main engine auxiliaries, and it was, of course, necessary to keep the voltage constant on the 300-kw. sets when using them in this way.

The main circulating pumps, main condensate pumps, main air pumps, and forced lubrication pumps, are motor driven and are run from the 300-kw. exciter sets in the centre engine-room. The condensate pumps are of the double-inlet volute type. The air pumps are of the reciprocating dry vacuum type, built by Wheeler Engineering Company. The main circulating pumps are built by the Alberger Company, and the forced lubrication pumps are of the Kinney rotating plunger type. The forced lubrication pumps supply oil for the turbo-generators, motor and thrust bearings, and also for the operation of the main governor hydraulic relay. The ventilating blowers for the main motors are also supplied with power from the exciting sets. The exciter switchboard is supplied with power from the ship's after distribution room, as well as from the exciters in the centre engine-room, and each of the motor-driven main engine auxiliaries is supplied with power from a double-throw switch which can be thrown to either the exciter bus or the ship's circuit bus, thus giving two sources of supply for current at all times. The various switches and levers used in the operation of the machinery are provided with interlocks, so that it is impossible to do any damage to the machinery through mistakes in operation.

The motor disconnecting switches and the generator disconnecting switches are provided with electric locks, so they cannot be moved unless the main generator field switch is open, assuring that all circuits are dead. The doors leading to the inside of the main switchboard are also electrically locked in the same manner; this prevents any one from getting at the bus-tie switch, which is located inside the switching structure, unless all circuits are dead. The bus-tie switch and the two generator disconnecting switches are mechanically interlocked so that only two of these switches can be closed at any one time, thus preventing putting the two main generators in parallel. They are also interlocked so that the generator disconnecting switches can be thrown only into the high-voltage position of the generator when the bus-tie switch is open, and only into the low-voltage position of the generator when the bus-tie switch is closed, thus insuring that the generator will always be run with low voltage when driving four motors and on high voltage when driving only two motors. The pole-changing and reversing levers are mechanically interlocked with the field levers, so that they cannot be moved unless the field lever is in the open position, thus insuring that all circuits are dead. The pole-changing and reversing levers are also electrically locked by an under-current relay on the main generator circuit which prevents these switches from being opened until the current in the main generator circuit has dropped to a predetermined value; this is an additional safeguard on the lock from the field lever which was added because it was found that the field lever could be operated so rapidly as to make it possible to open pole-changing and reversing levers with large currents still flowing, and while these switches are built to do this, it makes the operation very much easier on both the generators and the switches to allow a time interval of about 3 seconds before opening these switches. The pole-changing and reversing levers are mechanically interlocked so that the reversing levers cannot be thrown in the astern position unless the pole-changer is in the 36-pole position. This insures that the maximum torque of the motor will be available for reversing as the maximum torque is greater on the 36-pole condition than on the 24-pole condition. The field levers and speed levers are mechanically interlocked so that the speed lever is carried to the low speed whenever field is taken off the main generator. Also, any large increase of speed will carry the field lever with it, thus increasing the strength of the main generator field. This arrangement insures that large increases of speed will not be made without corresponding increases in the field strength, and it also insures that the turbine speed will be reduced before the reversal of the main motors is effected. In addition to these interlocks, there is provided a balanced relay which is energised by the two phases of the generator, and which is inoperative as long as the current strength in all four leads is the same; but if one of the phases should become short-circuited, the balance would be disturbed and this relay would trip out the main field switch.

The operation of the machinery is as follows:—

1. *Getting Under Way with One Generator and Motors on 36-Pole Connection.*—Assume that the ship is going to get under way with one generator, and that the maximum speed will not be over 15 knots. This means that the motors will be operated on the 36-pole connection. Before reporting ready to get under way, the generator that it is desired to use would be tested out and then set to run at low speed; the bus-tie switch would be closed, and the generator disconnecting switch would be closed in the low-voltage position. The field switch of the generator and the pole-changing and reversing levers would be open. On receiving a bell "ahead":—

(*a*) The pole-changing switch would be thrown in the "36-pole" condition.

(*b*) The reversing lever would be thrown in the "ahead" position.

(*c*) The field switch would be closed and brought up to the desired field strength.

(*d*) The turbine would then be brought up to the desired speed.

2. *Reversing.*—With the ship going ahead under conditions described above, under (1), on receiving a bell "astern":—

(*a*) The field switch would be opened and the speed lever brought to low speed at the same time.

(*b*) As soon as the under-current relay operates, the reversing levers would be thrown to the "astern" position.

(*c*) The field switch would then be closed and over-excitation applied to the generator until the motors have been reversed and come up to synchronous speed when the field would be reduced to its normal value.

(*d*) The speed of the turbine would then be brought up to whatever is desired.

3. *Getting Under Way with One Generator and Motors on 24-Pole Connection.*—In case it is desired to make the maximum speed greater than 15 knots, but less than 17½ knots, one generator will be used and the motors will be connected on the 24-pole condition. In this case, getting under way is exactly as described under (1), except that the pole-changing switches would be thrown into the 24-pole position.

4. *Reversing.*—Assuming the ship to have gotten under way with conditions as described above, under (3), on receiving a bell "astern," reversal would be accomplished in the following manner:—

(*a*) Open the field switch and throw the speed lever to low speed at the same time.

(*b*) Throw pole-changers to 36-pole position.

(*c*) Throw reversing switches to "astern" position.

(*d*) Apply over-excitation to the field of the main generator until motors have come into synchronism and then reduce field to normal value.

(*e*) Bring turbine up to desired speed.

5. *Getting Under Way with Two Generators.*—In this case, the bus-tie switch would be open and the two-generator disconnecting switches would be closed in the high-voltage position. Field switches would be open; generators would be running at slow speed and pole-changing and reversing switches would be open. If bell "ahead" is received, the operations carried out would be exactly as described under (3), except that it would be performed on two generators instead of one.

6. *Reversing.*—After having gotten under way with condition as above described, if a bell "astern" were received, the operations would be exactly as described under (4), except that they would be carried out for two generators instead of one.

The New Mexico has had two sets of official trials. The first trials were conducted after the ship had been out of dry dock about seven weeks, and this increased the shaft horse-power necessary to make the guaranteed speed of 21 knots by over 4,000 h.p., so a second set of trials were run when the horse-power came down to 29,100 for 21 knots. The ship averaged 21·08 knots for her 4-hour full-power run, and 21·31 knots was the average of the five high points on standardisation. The turbine water-rates were considerably better on the first trials than on the second, owing to the fact that the first trials were run in smooth water while the second trials were run in rough weather, which increased the horse-power for the speed, and for which no allowance was made, as the standardisation horse-power was used. The water consumption rates obtained on the trials were as follows:—

Speed.	Water Rate.	
	First Trial.	Second Trial.
Full speed	12·29	12·01
19 knots	11·926	12·33
15 knots	11·667	12·475
10 knots	14·223	13·96

These water rates include the steam for the 300-kw. exciters, which furnished power for excitation and also for driving the main air pumps, main circulating pumps, main condensate pumps, forced lubrication pumps, and ventilating blowers for the main motors. In addition to the trials for steam and fuel consumption, trials were made to demonstrate satisfactory backing qualities when steaming at full power; also to determine satisfactory performance when turning with full rudder and at full speed, both in the case of propulsion by one generator and also by two generators. Numerous other trials were conducted, such as standardising with two screws driving and two running idle, and considerable new data was obtained in regard to the action of screw propellers. In all the tests carried out, the machinery gave very satisfactory performance.

CRYSTAL PALACE ENGINEERING SOCIETY.—The "Wilson Premium" for the best paper read before this society (affiliated to the Society of Engineers) during the past session, has been awarded to Mr. G. M. Hall, for his paper entitled "Lighthouses and Their Construction." Other papers read during the session were "Glass and Its Manufacture," by Mr. T. Hyatt; "Railway Signalling," by Mr. E. W. Geary; "The Development of Brazil," by Mr. A. de P. Lopes; "The Railways of England," by Mr. C. J. J. Roberts; and "Canals and their Construction," by Mr. C. R. Selby. The premium was handed to Mr. G. M. Hall by Mr. W. Noble Twelvetrees, M.I.Mech.E., president of the Society of Engineers, on the occasion of the one hundred and thirty-ninth distribution of certificates at the Crystal Palace School of Practical Engineering, at which he presided, on April 16.

INDUSTRIAL NOTES.

We read in *The Labour Gazette* that during March there was a further increase in the number of persons unemployed, but this increase is more than accounted for by the number of demobilised men included, there being a decrease in the number of civilians whose policies were lodged. Although the number of unemployed is large, the process of reabsorption into employment of persons who have been recorded as unemployed showed an improvement during March, the percentage of civilians reabsorbed rising from about 40 per cent. at the beginning of the month to about 50 per cent. at the end, while the percentage for demobilised men remained steady at about 80 per cent. Increases in wages which came into operation in March affected over 200,000 workpeople, while 830,000 workpeople benefited by reductions in hours of labour. Retail prices showed a further decline, with the result that the general index number of retail prices of food and other items entering into the cost of living decreased from 115 per cent. to 110 per cent. above the pre-war level.

The total number of unemployed persons at March 28, according to the donation records, was 1,060,245, as compared with 948,620 a month earlier. The composition of the total at the end of March was as follows: (*a*) Civilians—Men 209,486, boys 26,461, women 488,655, girls 29,380; (*b*) Demobilised men 305,251, women 1,012. An analysis of 1,050,449 of the policies lodged at March 28 revealed that 23,666 of the unemployed persons were in receipt of the reduced donation which is paid to civilians after the expiry of the first period of 13 weeks' unemployment; of this number nearly two-thirds were women.

The number of men on the live registers of the Employment Exchanges on March 28 was 565,368, and the number of women was 563,190. The corresponding figures for February 28 were 416,150 and 549,261. The number of vacancies unfilled on March 28 was 46,591 for men and 65,145 for women, the corresponding figures for February 28 being 51,369 and 63,698.

Trade unions with a net membership of 1,206,899, excluding those serving with the forces, reported 2·9 per cent. of their members as unemployed at the end of March, as compared with 2·8 per cent. at the end of February and 1·2 per cent. a year ago.

Employment at coal mines continued good in March. The number of workpeople employed at the collieries included in the returns was 2·1 per cent. greater than in February and 9·8 per cent. greater than a year ago. At iron, shale and lead mines employment continued good, and at tin mines it was moderate. At quarries it was fairly good on the whole, but was much interrupted by bad weather.

In the pig-iron industry employment was still good, but some furnaces were damped down, and the number of furnaces reported in blast at the works covered by the returns was 10 per cent. less than a year ago. At iron and steel works employment continued good, and was better in the week ended March 22 than a month earlier, though not so good as a year ago. In the engineering trades employment was about the same as a month ago; on the whole employment was better with the more skilled than with the less skilled occupations. In the shipbuilding trades it was good on the whole. With tinplate workers employment was good—better than in February and much better than a year ago, the number of mills at work being greater than in March, 1918, by over 30 per cent. In most of the other metal trades employment was fairly good.

With dock labourers employment continued fair. The supply of seamen was greater than the demand. Skilled agricultural labour remained generally insufficient, but unskilled labour was equal to requirements in some parts of the country.

The change in rates of wages (including war bonuses) reported to the department as having come into operation in March resulted in an increase of about 40,000*l.* in the weekly wages of over 200,000 workpeople. The principal change was that affecting boot and shoe operatives, whose wages were increased by the introduction of new minimum rates, which applied generally to the whole of Great Britain.

The changes during March in the number of hours constituting a full ordinary week's work, in the industries for which statistics are collected by the department, affected over 830,000 workpeople, whose recognised hours were reduced by an average of about 7½ hours per week.

The complete figures of the miners' ballot have been announced since the printing of our last issue. They are as follow:—

For accepting the Sankey Report	693,084
Against	76,992
Majority	616,092

An amazing decision under the Workmen's Compensation Act was recently given in the Dumbarton Sheriff Court in favour of the claimants, the wife of a miner and their two children, who sued the Woodilee Coal and Coke Company for 300*l.* in respect of the death of their husband and father, who, in the latter end of September, was killed in an explosion at Meiklehill Colliery, caused by him through lighting a match.

The sheriff found that the explosion was due to the fact that the miner struck a match to light his pipe during the customary knock-off period in the middle of the shift. Not only is the striking of a match in a pit an offence under the Coal Mines Act, but the mere fact of a miner having matches in his possession in a pit is equally an offence under that Act, and the miner in question was aware of this. The sheriff, notwithstanding, found the company liable, and assessed the compensation at the above sum, with costs.

The sheriff stated it was maintained the accident did not arise out of the employment, but out of the miner's lighting a match for his own purpose. That was the contention sustained in the Hamilton case. He regretted he could not agree. But for the rules the miner, upon whose case he was adjudicating, disregarded, there was nothing unreasonable in what he was doing, "and a breach of rule was not sufficient *ipso facto* to take a man outside the sphere of his employment." Viewing the case from the point of view of added peril, he said that the peril in the present instance, the chance of an explosion, was peculiarly incident to the employment, existent regardless of the man's conduct. What the man did did not create the peril, it caused the peril to materialise.

Speaking last week at the fifty-ninth annual meeting in London of the Association of Chambers of Commerce of the United Kingdom, Mr. E. Manville, M.P., the president, said that the Government, and, indeed, the whole country, realised that better conditions must be provided in the lives of the workers of the nation. The employers of the country, with the greatest unanimity, were prepared to do all that was possible in materially advancing the standard of wages as compared with that which prevailed before the war. It was recognised that the keystone of industry was labour. Suitable provision must be made to rid the workers of the common fear of the evils of unemployment and underemployment. It was an uncontrovertible fact that, in the past, the workers of this country had failed to put forward their best efforts at their work and, on the contrary, as a matter of policy, had limited their possible output. This could easily be understood in view of the fear they had, of possible unemployment; but it was to be hoped that, with that fear removed, there would be a genuine willingness on the part of workers to produce the most they could during the hours they were working.

The Institution of the National Industrial Council would, he believed, receive almost unanimous approval amongst industrialists, and it was certainly the most important step ever taken in respect to the relations of employers and employed. Employers were very willing to contemplate a permanently higher standard of wages, and a lower standard in the number of hours worked; but they were bound to look at the possible effect which this might have on the prosperity of the country. While it might be possible to exist on the home market to a large extent, it was not, in his opinion possible to bring these great reforms into being, and to continue them, without the profits derived from our large export trade; and the productive costs of the country must be reduced at least in proportion to the increase in the rates of wages and the decrease in the hours worked. Otherwise, the price of our commodities would be such that our export trade would vanish, or, at all events, be largely reduced.

He hoped and believed that the new conditions which now confronted us would not only cause the trade unions to remove their restrictions as to output, but that the leaders in these trade unions would see to it that their members were made fully acquainted with the absolute need for a reversal of the former policy of restricted output. They could not fail to realise that (even if the restrictions on output were removed) the materially higher wages which would be earned might tend to induce less effort on the part of those earning them, who might be content to make only that effort which would bring in what they considered a sufficient sum each week. That this policy would bring disaster in its train was self-evident, and there were already signs in some industries of men producing a smaller output than in the time before the war.

Unless a speedy improvement took place, it was certain that in many directions we would lose our export trade. Already there was evidence of this possibility in the export of coal, countries which had heretofore taken coal from the United Kingdom having placed their contracts with the United States. If we could rely on the efforts of the workers of the country, the prospects of our export trade were remarkably good. The whole world outside the belligerent countries had had but a modicum of its wants supplied during the years of war, and there must inevitably arise a keen demand for manufactured goods of all descriptions. It seemed to him that it was for the workers to decide whether or not this country should share in the times of good trade which were before us.

A Bill introduced by Sir Robert Horne, the Minister of Labour, was read a first time in the House of Commons on the 15th inst. It provides for the restoration after the war of "certain trade practices and to amend the law relating to munitions tribunals."

Clause 1 deals with the restoration of these practices, and is divided into six subsections.

Subsection 1 states that in any establishment to which the bill applies, where practices or customs have been departed from in consequence of the war, the owner shall be under an obligation, at the expiration of one month from the receipt of a specified notice, to restore, or permit the restoration of, such trade practices for the period of one year.

New establishments or branches are dealt with on similar lines in Subsection 2.

Subsection 3 contains a provision to the effect that an obligation under this section shall not become binding on the owner of any establishment unless within three months after the termination of the war there is served on him by or on behalf of a majority in the establishment of the class or grade of workers whose custom it was before the war to maintain the trade practice in question a notice requiring the observance of the obligation. If the owner of the establishment is not prepared to comply with the notice, or is in doubt as to its nature, it is provided in Subsection 4 that he must give a counter-notice within 14 days of the receipt of the notice.

Where such a counter-notice is given, Subsection 6 provides that either party may apply to a munitions tribunal of the second class to determine whether the obligation exists or, as the case may be, the nature of the obligation. Any order made by the tribunal shall be conclusive in any proceedings that may subsequently be taken against the owner in the matter.

Clause 2 imposes a penalty not exceeding 25*l.* for each day or part of a day during which failure to comply with an obligation under the Bill shall continue. A trade union or federation of trade unions may institute proceedings against an employer for an offence under the Bill.

The powers of the Minister of Munitions in relation to munitions tribunals are transferred by Clause 3 to the Minister of Labour.

The establishments specified under Clause 4 are those in which munitions work has been carried on, and any other establishment in which departure from practice was made in consequence of the Treasury agreements of 1915.

Subsection 2 of this clause places crown establishments under the purview of the Bill, and makes them liable to similar proceedings as a privately-owned establishment.

The sittings of the Coal Industry Commission have been resumed to consider the question of the Nationalisation of Mines. Sir Allan M. Smith, K.B.E., has been appointed a member of the Commission in the place of Sir Thomas Royden, Bart., M.P., who has resigned owing to ill-health and his inability to devote the necessary time to the work of the Commission.

According to a correspondent of *The Times*, writing from Vancouver, the announcement that Messrs. Yarrow intend gradually to remove the bulk of their industry from the Clyde to the Pacific Coast has aroused much interest in British Columbia. Meanwhile a Royal Commission is in session in Vancouver inquiring into the conditions existing in the largest shipbuilding yard there—that of Messrs. J. J. Coughlan.

The main points in the inquiry centre upon the very conditions which, Sir Alfred Yarrow states, are influencing his firm in moving from the Clyde to British Columbia. The Coughlan firm claims that through the Radical-Socialistic influences at work among the union men employed in the yards, output has been deliberately restricted to such an extent as to be a serious handicap to the industry. The price of production in British Columbia is set at approximately 200 dols. (40*l.*) per ton, compared with 120 dols. (24*l.*) in Great Britain. Such competition cannot be met successfully, it is declared, under present industrial conditions.

The British Columbia Government has set aside 10,000*l.* for the purpose of conducting experiments in iron smelting and steel production from local ores. The lack of any such industry has added enormously to the handicap of the shipbuilding industry.

H.M.S. WIVERN.—Messrs. J. Samuel White and Co., Limited, East Cowes, launched another ocean-going destroyer—the Wivern, 1,400 tons displacement and 28,000 shaft horse-power—for the Admiralty on Wednesday, the 16th inst.

THE SUPERHEATING EFFECT OF A REDUCING VALVE.

To the Editor of Engineering.

SIR,—I recently carried out a test to determine the superheating effect of a reducing valve placed in a 10-in. pipe line from a battery of Lancashire boilers. The reducing valve was 500 yards away from the boiler-house and the pipe was lagged and fitted with the usual traps, the steam was supposed to be almost dry. The steam flow was 30,000 lb. per hour when the observations were made.

The mean of 12 readings gave :—

Pressure before valve, 143 lb. per square inch gauge.
Temperature before valve, 362·5 deg. F.
Pressure after valve, 90 lb. per square inch gauge.
Temperature after valve, 331 deg. F.

The temperatures corresponding to the pressures from the tables are 362·2 deg. and 331 deg. F. respectively, showing that there was no superheating effect. Reference to the Mollier diagram shows that the steam should have been superheated 10 deg. F. after it had passed reducing valve if the steam was dry saturated at higher pressure. The steam in expanding must therefore have given up the difference of its total heats at the respective pressures to evaporating water present at the higher pressure.

The difference in the
total heat per pound = 1,192·4 — 1182·9
At the two pressures = 9·5 B.T.U. per lb.

For each pound of steam flowing, therefore, 9·5 British thermal units were available for evaporation.

The sensible heat is lower at the smaller pressure by 330 — 299 = 31 British thermal units, 330 and 299 being the heat units required to raise the temperature of each pound of water from 32 deg. F. to the temperature at which it exists as steam. The amount of heat required to evaporate 1 lb. of water at the higher temperature will therefore be the latent heat per pound at the lower pressure minus 31, or 881 — 31 = 850 British thermal units per pound.

During the above test, therefore, for each pound of steam passing the valve $\frac{9 \cdot 5}{850}$ lb. of water at least must have been present, *i.e.*, 1·12 per cent. It was not possible to vary the weight of steam passing the valve or to measure the actual wetness of the steam.

I send this result as it may interest some of your readers who have to deal with steam problems. It would be interesting to know what effect the work of Mr. Aspinal of the Finsbury Technical College would have on the working out of these results. His statements referred, I believe, to the latent heat of steam, which he said should be constant at all pressures and not as Regnault found, decreasing with increasing pressure. Perhaps he or other of your readers who know the exact nature of his work could write on this point.

Yours truly,
N. H. HUNT.

19, Mornington-crescent, London, N.W. 1,
April 13, 1919.

THE NATIONALISATION OF INDUSTRIES.

To the Editor of Engineering.

SIR,—I have been reading the leading article on "Railway Nationalisation" which appeared in your issue of December 13 last, page 683. I may say I agree with every word in that leading article.

It has always been a surprise to me that trade unionists could be in favour of nationalisation of any industry in which organised labour was employed. We have had during the war an object-lesson in the form of a working model of what nationalisation must lead to, under which men were not allowed to leave an employer engaged in certain industries controlled by Government to apply for a position in the same industry in other towns without consent. In other words, under nationalisation we revert back to the old days, long ago abolished, and which we thought never would return, when the workman could not leave the spot on which he was born without the consent of his over-lord. The Government would become the over-lord and the only employer of labour, and all the variety and freedom to seek employment wherever the workman might desire would disappear.

There would be no collective bargaining by the trade unions either for wages or conditions of employment. The Government would be the one employer and the workman's remedy would only be at election time and at rare intervals, when by his vote he might attempt to exercise a power which is now exercised by his trade unions. To the extent that the exercise of this power was against the interests of his fellow citizens, then nationalisation would make the workman into a bad citizen, as he would be setting his own private interests as a workman in priority to the interests of the country, and, as I hope, he would be too good a patriot to do that, then his own private interests would not even have that opportunity of asserting themselves. But the workman is not only in receipt of wages for his work, but the wages require to be exchanged for commodities essential for comfort and welfare, such as house rent, food, clothing, &c. Nationalisation of railways and coal mines would be followed in all probability by nationalisation of other industries, and even of distributing businesses of the retail shopkeeper.

Under the present system the workman and his wife have liberty to spend their wages where they can get the best value and to leave one shopkeeper who is inattentive to trade at another shop. Under nationalisation they would lose this liberty, as there would be only one shopkeeper, and that would be the Government. If the manager in a Government shop were insolent or inattentive, there would be no effective remedy as there is at present, and it might even be, as was the case under the Food Control when a purchaser was limited to certain defined shops to which each citizen might be allotted, for the purchase of margarine, tea, &c.

All I can see in proposed nationalisation is the growth of bureaucracy with all its wasteful extravagance in production and management, and the absolute surrender by the citizen of that liberty which we have fought hard for through the centuries. We instal the Government as autocrat over our lives and liberties, to fix our wages and the price of the commodities to be purchased by our wages, and this finally would destroy that active spirit of service for our fellow man which is of natural and spontaneous growth under individualism.

In short, were nationalisation to be applied generally, the workman would be in exactly the same position as the post office employee. He would have only one master, and his trade unions would be obsolete. His only opportunity of expression of opinion would be at election times when recording his vote, and this would be a very transient power, and one that could scarcely be used honestly except in the interests of the whole community. If his vote were used selfishly for individual interests, then would speedily follow the disruption of the British Empire, and it would be beyond our power to keep Great Britain and the British Empire on the map of the world.

Yours sincerely,
LEVERHULME.

The Hill, Hampstead Heath, London, N.W. 3,
April 23, 1919.

INJECTION OF WATER INTO INTERNAL-COMBUSTION ENGINES.

To the Editor of Engineering.

SIR,—I find that in copying my letter of March 11 (published in your issue of March 21, page 371) a portion of it relating to the wrong way in which in some hot-bulb engines water is introduced, was altered so that it does not represent what I meant to say.

If the water drips in the air while being drawn in, it is not soon enough volatilised to prevent it from coming into contact with engine parts which are too cool for causing it instantly to evaporate. The quantity of water for each power stroke must be proportioned to the quantity of fuel, and it must be injected in such a way that it cannot hit, while still being in a liquid state, any other engine part than the hottest portion of the hot bulb.

Yours faithfully,
A. F. VAN AMSTEL.

Amersfoort (Holland), April 10, 1919.

CRITICAL SPEED OF SHAFTS.

To the Editor of Engineering.

SIR,—May I draw the attention of your contributors and readers to a paper on the above subject in the *Schweizerische Bauzeitung*, November, 1918, by Professor Ernest Hahn.

The solution is found by a very elegant piece of analysis in the form of a rapidly convergent series in even powers of ω. If terms in higher powers of ω^4, ω^6, &c., are neglected, Dunkerley's well-known rule is obtained. In an example on a shaft carrying two discs the maximum error, which depends on the positions of the discs, is about 5½ per cent. The inclusion of the term in ω^4 makes the error negligible.

I am, &c.,
A. R. LOW.

Technical Publications, Room 361, Central House,
Kingsway, W.C. 2, April 17, 1919.

"COAL SAVING AND SCIENTIFIC CONTROL OF STEAM BOILER PLANT."

To the Editor of Engineering.

SIR,—In your issue of 21st ult. there is a letter on Lancashire boilers, from Mr. James Dunlop. As it appears to contain several errors, and as Mr. Dunlop's expression of his views on "the law that connects the rate of combustion with steam boiler proportions and performance" is capable of a wider interpretation than he probably intended, and may mislead young engineers who are endeavouring to get a grasp of the matter, I venture to make the following remarks.

As a matter of fact the design and proportions of a Lancashire boiler depend upon a multiplicity of considerations that have nothing to do with the amount of air admitted to the furnaces per pound of coal burned and the efficiency resulting therefrom.

Because of possible variations in quality of coal, in quantity of scale on water surfaces, of soot on heating surfaces, and of chimney draught (owing to wind and weather), a very moderate efficiency—say, 65 per cent.—must be assumed by the designer, and anything better that may be obtained at any time is so much added to reserve of power.

The designer should begin with the grate surface, which is at the source of the power required, should fix the length of grate that can be properly manipulated—if hand-fired—or that will suffice for the proper burning of the fuel if mechanically fired, and determine the amount of fuel that can be burned per square foot of grate under the worst conditions, and from these fix the widths of grates, or diameter of furnace tubes—from which the diameter of boiler naturally follows.

For a hand-fired boiler (say, 8 ft. by 30 ft.), worked with moderate chimney draught only, and for grates (say 5 ft. long) fitted with suitable firebars—say, 1½ in. thick at face, with ½ in. air spaces—from 15 lb. or 16 lb. to 26lb. or 28 lb. of good Welsh steam coal can be burned, per square foot per hour, according to the lift of the flue dampers.

The heating surface of such a boiler is usually about 25 times the grate surface—not 50 times, as suggested by Mr. Dunlop, and the average quantity of water evaporated per square foot of heating surface, as found from very numerous experiments made during the past fifty years, may be taken at 5½ lb. per hour; for, of course, this quantity varies greatly at different parts of the heating surface, being very much greater at the furnace crowns over the fuel, and very much less at the tail end of the return flue under the boiler.

From the above-mentioned data all dimensions of the boiler follow, except scantlings, &c., which can be obtained by calculation from such rules as those published by the Board of Trade.

The grate surface of an 8-ft. 6-in. by 30-ft. Lancashire boiler would be about 35 sq. ft., not 21 sq. ft. as suggested by Mr. Dunlop, who, perhaps, has taken one furnace and forgotten to double the area. Hence, also, his coal per square foot of grate is a good deal too high.

The evaporation he gives, viz., 9·2 lb. of water per pound of coal can, of course, only be obtained by using good steam coal; with rough small coal and mechanical stoking 7 lb. of water would rarely be exceeded.

His third quantity, viz., 1,462/262·4 = 5·57 is not rational, and rather suggests some of the ancient jokes, such as "Divide the diameter of the low-pressure cylinder, in inches, by the pitch of the propeller in feet, and the square root of the quotient multiplied by the diameter of the funnel in feet will give the captain's name."

Several of his other quantities are not relevant.

The best quantity of air and rate of combustion for highest efficiency can be determined by experiment, but they depend so much upon the coal and the general arrangement and construction of the plant that it is very doubtful whether the quantities and rates would be found even approximately similar for any two plants chosen at random.

I am, Sir, yours truly,
"R."

THE SURVEYORS' INSTITUTION: THE INSTITUTION SCHOLARSHIPS.—The Council of the Surveyors' Institution announce that with the conclusion of the war the Institution scholarships are again being offered. Four scholarships are open for competition yearly, two of the value of 80*l.* and two of 50*l.* They are tenable for three years at any recognised university in the United Kingdom selected by the successful candidates, and in any course of study leading up to an honours degree approved by the council as bearing on and of advantage in the training for any of the branches of the surveyor's practice. The object of the council in offering these scholarships is to afford those who will in the future practise as surveyors the highest form of professional education obtainable, and thus to raise the standard of professional education and attainment. The next competitive examination will take place in January next, and will be carried out by the Oxford and Cambridge Joint Board at centres selected for the convenience of candidates. Further particulars may be obtained from the Secretary, 12, Great George-street, Westminster, S.W. 1.

ACCIDENT ON THE GREAT EASTERN RAILWAY.—An accident which occurred at Wood-street Station, Walthamstow, on the Great Eastern Railway, on February 13 last, was due, according to the Board of Trade report, to the "quite exceptional case of failure of a semaphore arm." At the time of the accident an empty-carriage train was standing at Wood-street Station when it was run into by the 8.40 a.m. down passenger train from Liverpool-street to Chingford. There was some damage to stock, and a number of employees and passengers were injured, but none seriously. A "section clear but station blocked" signal is allowed at Wood-street Station for the acceptance of a train from Hoe-street, to previous station. To ensure, however, that the down home signal for Wood-street is at "danger" before a train is thus accepted, the position of the semaphore arm is electrically detected by means of interlocking with the Sykes' down plunger instrument at Wood-street. The signalman must release the plunger of the instrument by pressing a push button, and the release is not given unless the arm of the down home signal is at "danger." On the morning of the accident it was foggy and the signal could not be seen from the signal cabin. The signalman, on trying to plunge on his down-line instrument, failed, and after operating the signal lever more than once decided that the instrument had failed and telephoned to Hoe-street to that effect, and accepted the 8.40 train. The driver of this train was advised of the failure of the instrument, but when he reached the down home signal for Wood-street found it lowered, and proceeded, with the result that the collision took place. Investigation later showed that it was not the block instrument which had failed, as supposed by the signalman, but that the semaphore arm of the down home signal had become fixed in the lowered position so that when the lever in the cabin was moved to "danger" the signal did not move correspondingly. It was found that two of the three screws which hold the striking plate to the lower edge of the semaphore arm had dropped out and that the third screw was also loosened and that the plate had swung round on this screw and become wedged on the top edge of the angle-iron arm-stop.

THE TONNAGE OF MODERN STEAMSHIPS.*

By A. T. WALL, A.R.C.Sc., Member.

1. THE main object of this paper is to focus attention on the effect of recent legislation and modern machinery on tonnage measurement. Some remarks on the basis of measurement are also made.

2. *Basis of Measurement.*—It will not be out of place to touch on the principle underlying the whole question, especially as it is thought by many that the present method is not only complicated but unfair as between ship and ship. The subject is obviously quite unsuitable for exact mathematical treatment, and it must be recognised that whatever basis is used, anomalies are bound to occur.

3. This side of the matter has been dealt with by Mr. E. R. Johnson in his book on "Measurement of Vessels for the Panama Canal." He gives several bases that have been proposed for tonnage measurement, and considers them in a general way in coming to the conclusion that the only fair and practicable method is the present one of assessing the earning spaces in the ship. The measurement of vessels for the Panama Canal is very similar to that under the Suez Canal Rules, which is the same in principle in all maritime countries.

4. The proposed bases are as follows :—

(1) Gross deadweight.
(2) Cargo deadweight.
(3) Block displacement (length × beam × draught).
(4) Displacement.

5. Gross deadweight is obviously an unfair method, as it takes no account of the passengers carried in the ship usually having a small deadweight.

6. Cargo deadweight would be very difficult if not impracticable to assess, and, to be logical, would vary under different conditions, requiring repeated measurement. The same objection as to passengers applies as in paragraph 5. Further, ships carrying no cargo would have no tonnage.

7. Displacement tonnage would appear to be fairer than the foregoing. This tonnage is made up of the light weight of the ship and the gross deadweight. The former is heavier in a passenger ship than in a cargo vessel of the same length for many reasons ; among these are greater superstructure and heavier machinery. In addition, large quantities of fresh water, stores, baggage, &c., must be carried for the passengers. This excess weight gives a measure of the passengers carried.

8. A great advantage of displacement tonnage would be that it is easily measured, and a certified displacement scale would be carried by the ship. The tonnage on this basis would also vary with the loading of the ship and so be more commensurate with her earning capacity and the services rendered to her for which dues are levied.

9. Block displacement tonnage is similar to displacement tonnage, but is severe on vessels of fine form.

10. It would be impossible by any system to take an accurate measure of the value of the cargo and the revenue from passengers, even if this were a proper basis for tonnage dues, which is doubtful. It would be equally impossible to measure properly the actual service performed by any port, canal, &c., to a particular ship. Any basis must be somewhat arbitrary, but the existing method does, or at least could, be made to give a true measure of the earning spaces in a ship.

11. Table I gives particulars of various vessels, showing how the bases compare.

12. From Table I it is evident that no two bases will give corresponding results, but it shows that there might be some justification for a displacement basis or a block displacement basis.

13. *International Tonnage.*—Although the principle of measuring the actual earning spaces of a ship is adopted in all maritime countries, there are many variations in details which give the same ship very different tonnages under different rules. Gross tonnages do not vary greatly except on account of the exemption for shelter-deck and certain superstructure spaces as allowed under British rules. This causes very different values, for instance, between American and British measurements. One example is sufficient as an illustration. A British ship, with shelter-deck spaces exempt, has a gross tonnage of 4,435, whereas under American rules it is 5,470, an increase of 23 per cent. The German rules make the same allowance as the British. It is often maintained that there is no justification for the exemption of the shelter 'tween-deck spaces. The tonnage laws of the American, Suez and Panama Canal authorities do not recognise it.

14. The allowances for net tonnage are very varied. Taking the same ship as in paragraph 13, her tonnages are as follows :—

—	Gross.	Net.	Percentage Increase Net Tonnage over British.
British	4,435	2,808	—
American	5,470	3,512	25
Suez Canal	5,478	4,203	50

15. Table II, taken from the book by Mr. Johnson already referred to, shows how greatly the deduction for net tonnage varies under different rules.

16. The disadvantages of varying rules are to some extent overcome by agreements between countries to take one another's figures, but in many cases additions are made, especially where the tonnage is much less than it would be if measured by the country collecting the dues.

17. The International Tonnage Commission, which met at Constantinople in 1873, drafted rules for the Suez Canal Company which it expected would have been adopted internationally.

18. The chief causes of variation in gross tonnage are the exemption of shelter-deck and superstructure spaces, while the particular rule adopted for propelling space deduction has most effect on the net tonnage. There are, however, many other differences which cannot be justified.

19. International rules should be instituted, and, if taken up in the right spirit, would not be difficult to bring about, especially from a technical standpoint.

20. *Tonnage and Freeboard.*—The existing Tables of Freeboard take account of the form of the vessel by using the tonnage coefficient. It is stated in the tables that this coefficient bears a constant relation to the whole external volume of the ship below the upper surface of the deck divided by the product of length × breadth × depth. This tonnage coefficient was adopted in the Tables of Freeboard to make the tables easily and directly applicable in cases where a displacement scale for a vessel is not at hand. In practice, for new ships, the tonnage coefficient is deduced from the displacement coefficient which is the only thing known in the design stage, so that the method adopted by the Committee on Load Lines in their report issued in 1916 (where they use the moulded displacement coefficient at a draught which is 85 per cent. of the moulded depth to the freeboard deck), is much simpler, and will be welcomed when the report referred to becomes law, as it is understood will be the case.

21. There are also minor objections to the use of the tonnage coefficient for determining freeboard. In the first place, there is a good deal of work involved in correcting the tonnage coefficient for the standard sheer and round of beam, and also for the type of bottom construction adopted.

22. Further, this tonnage coefficient is intended to take account of the fineness of the ship up to the freeboard deck. The freeboard deck may, or may not, be the tonnage deck, and the position of the tonnage deck will depend on the number of complete decks carried, it being the second complete deck from the bottom. There will, accordingly, be a small variation in freeboard with the number of complete decks carried, which should not be the case.

23. *Tonnage and Subdivision.*—The exemption of shelter 'tween-deck and other superstructure spaces has been referred to in paragraph 13. It is doubtful, in passenger ships, owing to the present subdivision rules, whether it would be possible to exempt many such spaces.

24. To be exempt from tonnage, a shelter 'tween-deck must have a tonnage opening, openings in the transverse bulkheads, and scuppers discharging overboard from the deck under the shelter deck, that is, the upper deck.

25. The freeboard of such vessels brings the load draught only a little below the upper deck. If the upper deck is retained as the bulkhead deck it generally becomes necessary to put in so many bulkheads to meet the subdivision requirements as to make the ship impracticable. The alternative is to carry the watertight bulkheads up to the shelter deck. The necessary tonnage openings in these bulkheads cannot then be fitted, and the scuppers in the upper deck must also be omitted. This matter was discussed in detail by the author in a paper read before this Institution in 1916 on "Some Effects of the Bulkhead Committee's Rules in Practice."

26. The inclusion of the shelter 'tween-decks in the tonnage will increase the gross and the net tonnages. If the propelling space is still large enough with the light and air spaces to be over 13 per cent. of the new gross, the increase in net tonnage will be of the order of 25 per cent. It may be, however, that the propelling space may not be large enough to be over 13 per cent. of the gross, when the increase in net tonnage may be as much as 50 per cent. This is a very serious disadvantage of the subdivision rules.

27. One other case of a similar nature may be briefly mentioned. It occurs mainly with home trade passenger and cargo steamers of the three-island type. To subdivide adequately such vessels it will be necessary to fill in one or both of the wells, making the vessel flush deck forward or throughout. This adds to the tonnage, and although the wells are used to carry cargo on occasions, they are not always included in the tonnage measurement. An example of this is given in the paper referred to in paragraph 25, and the increase of net tonnage may be about 20 per cent.

28. *Deduction for Propelling Spaces.*—The British law for propelling space allowance in screw steamers provides that when the tonnage of the space solely occupied by

TABLE I.

No. of Ship.	Moulded Dimensions.	Draught.	Speed.	Total Number of Passengers.	Net Tonnage.	Gross Deadweight. Tons.	Gross Deadweight. Ratio to Net Tonnage.	Cargo Deadweight. Tons.	Cargo Deadweight. Ratio to Net Tonnage.	Block Displacement.* Cubic feet, ÷ 100.	Block Displacement.* Ratio to Net Tonnage.	Load Displacement. Tons.	Load Displacement. Ratio to Net Tonnage.
		ft. in.	knots.										
1	235′ × 34′ × 17′ 3″	15 11	8½	None	782	1,660	2·12	1,270	1·625	1,272	1·625	2,750	3·52
2	300′ × 45′ × 23′ 6″	20 11	14	116	1,835	3,135	1·71	2,230	1·215	2,827	1·54	5,933	3·23
3	312′ × 40′ 9″ × 26′	22 9	9	8	1,859	4,175	2·245	3,360	1·81	2,893	1·555	6,035	3·245
4	345′ × 43′ 9″ × 27′	23 1	11½	420	2,166	4,065	1·875	2,500	1·115	3,490	1·61	7,027	3·245
5	375′ × 47′ 3″ × 29′	24 4½	14½	519	2,497	4,270	1·71	2,700	1·08	4,319	1·73	7,980	3·20
6	376′ × 50′ × 34′	25 8	11	146	3,512	7,450	2·12	5,640	1·61	4,826	1·37	10,970	3·12
7	390′ × 51′ 3″ × 29′	23 11	11	None	3,110	7,386	2·375	6,200	1·995	4,781	1·54	10,383	3·34
8	400′ × 49′ 9″ × 30′	25 7	13½	517	3,223	5,780	1·79	4,060	1·26	5,057	1·57	10,135	3·14
9	400′ × 52″ × 31′	25 2	11½	None	3,178	8,180	2·575	7,280	2·29	5,138	1·615	11,485	3·61
10	410′ × 53′ × 30′ 6″	24 5	11	None	3,210	8,260	2·57	7,356	2·29	5,300	1·65	11,520	3·59
11	530′ × 64′ × 40′ 6″	31 6	17	1,300	7,598	11,750	1·55	7,700	1·015	10,685	1·405	21,600	2·84
12	530′ × 66′ × 45′	34 0	15	650	8,720	16,340	1·87	9,940	1·14	11,890	1·365	25,940	2·975
13	570′ × 69′ × 42′ 3″	31 7	11	None	9,780	19,815	2·025	18,362	1·88	12,420	1·27	27,330	2·795
14	600′ × 73′ × 45′	35 6	16	2,400	12,920	18,790	1·455	14,700	1·14	15,565	1·205	32,810	2·54
	Average value of ratio to net tonnage					—	2·00	—	1·53	—	1·51	—	3·19
	Mean percentage variation from the average ratio ..					—	14·5	—	25·8	—	8·5	—	7·8

* Length × breadth × draught.

TABLE II.—*Gross and Net Tonnages of the Metal Steam Vessels of the World*, 1910, *and the Percentage Deducted from the Gross in Ascertaining the Net.*

Flag.	Gross.	Net.	Per Cent. Deducted.
Argentinian	139,346	82,418	40
Austro-Hungarian ..	777,240	485,675	37
Belgian	295,913	194,336	34
Brazilian	232,425	142,582	38
British	17,940,862	10,893,898	39
Chilean	114,067	72,608	36
Chinese	84,800	54,526	35
Cuban	52,494	32,165	38
Danish	668,836	391,788	41
Dutch	982,104	607,286	32
French	1,445,422	835,016	42
German	3,959,147	2,416,370	39
Greek	498,281	312,296	37
Haitian	3,387	2,017	40
Italian	985,716	597,640	39
Japanese	1,064,169	675,983	36
Mexican	27,324	16,513	39
Norwegian	1,385,631	838,320	37
Peruvian	10,371	5,354	48
Portuguese	78,829	48,677	38
Roumanian	31,688	16,600	47
Russian	687,231	400,761	41
Sarawak	3,953	2,380	39
Siamese	12,607	7,792	38
Spanish	746,047	459,198	38
Swedish	756,909	449,872	40
Turkish	110,770	68,755	37
United States (excluding Northern Lakes)	1,439,911	939,505	34
Uruguayan	48,337	30,115	37
Venezuelan	3,166	1,856	41
Other flags	20,657	11,869	42
Philippine	32,287	20,834	35
Total (national) ..	34,639,927	21,115,093	39
Suez Canal	23,054,901	16,581,898	28·07

TABLE III.

Type of Ship.	Type of Machinery.	Percentage Reduction in Propelling Space on Space Occupied by Old Machinery.
1. 600-ft. intermediate passenger and cargo steamer	Coal-fired cylindrical boilers and double reduction geared turbines	13
2. ,, ,,	Oil-fired water-tube boilers and double reduction geared turbines	33
3. 530-ft. intermediate passenger and cargo steamer	Coal-fired cylindrical boilers and double reducton geared turbines	10
4. 400-ft. cargo steamer	Camellaird-Fullager oil engines	37
5. 400-ft. cargo steamer	Coal-fired cylindrical boilers and Ljungström turbo-electric engines	10
6. 150-ft. coaster ..	Camellaird-Fullager oil engines	20

* Paper read before the Institution of Naval Architects, April 11, 1919.

and necessary for the proper working of the boilers and machinery is above 13 per cent. and under 20 per cent. of the gross tonnage, the deduction shall be 32 one-hundredths of the gross tonnage. If the space does not lie between these limits the deduction is 1½ times the actual space.

29. This rule was adopted in 1854, when tank boilers and reciprocating engines were the principal power units and coal the main fuel. Since then, and especially during the last ten years, great advances have been made with propelling machinery. Modern machinery, such as geared turbines, water-tube boilers, oil engines, electric transmission and oil-fired boilers, occupies much less space for the same power than the old machinery. Consequently modern machinery often occupies less than 13 per cent. of the gross tonnage.

30. The result is a considerable increase in net tonnage, quite out of proportion with the increase in cargo space, as evidenced by the following example :—

Ship with Old Machinery.

Ship dimensions (moulded)...	580 ft. by 70 ft. by 45 ft.	
Gross tonnage		20.000
Deductions for crew spaces, &c.	1,350	
Propelling space with coal-fired cylindrical boilers and Q.E. reciprocating engines	2,800 (14 per cent. of the gross)	
Deduction on account of propelling space (32 per cent. gross)	6,400	
Total deductions		7,750
Net tonnage with old machinery		12,250

Ship with Modern Machinery.

Gross tonnage (as before)...		20,000
Deduction for crew spaces, &c. (say, as before) ...	1,350	
Propelling space with oil-fired water-tube boilers and double-reduction geared turbines (10 per cent. of gross)		
Deduction on account of propelling space, 10 per cent. by 1½ per cent. of gross	3,500	
Total deductions		4,850
Net tonnage with modern machinery		15,150
Increase in net tonnage ...	24 per cent.	
Increase in cargo space ...	5 per cent.	

31. The propelling space with the old type of machinery may be so little above 13 per cent. of the gross tonnage that the substitution of geared turbines of the same power for reciprocating engines, and retaining the coal-fired cylindrical boiler, decreases the engine-room space and the boiler-room space so much as to bring the propelling space below 13 per cent. of the gross tonnage. Actual cases of this have come under notice.

32. Some actual cases of the percentage reduction in propelling spaces are given in Table III on page 549.

33. The progressive shipowner who adopts modern machinery will therefore generally lose money by paying high tonnage dues, abroad as well as at home, or by deliberately making unnecessarily large machinery and light and air spaces and so wasting cargo and passenger space. The latter course may not be successful, as the Board of Trade have power to refuse to allow space in the measurement if it is not reasonable in extent for the intended purpose.

34. There is, of course, some gain in cargo space to set off against the increase in net tonnage, but it is not proportional. Examination shows that the result is a net loss. In case 2, Table III, the gain in cargo space is 6 per cent., and increase in net tonnage 26 per cent. The annual loss in revenue has been estimated to be 4,000*l*.

35. The present rule fixed 13 per cent. to provide comfort for those who had to look after the machinery, and the 32 per cent. reduction was made to compensate for bunkers. There does not appear to be any justification for this percentage rule, and in view of its unfair incidence in many modern vessels, the question naturally arises as to whether it ought not to be dropped, and replaced by a rule which gives some multiple of the propelling space as allowance for bunkers.

36. To say that, as yet, few ships are affected is not strictly true, and even if it were so legislation should anticipate progress and help it.

37. As the British tonnage regulations have been adopted by a large number of nations, alterations would probably have to be made by international agreement, and the British law now regulating tonnage measurement would have to be altered by Act of Parliament. In the meantime a proposal is put forward for meeting the case. It is not thought fair that ships with propelling spaces not exceeding 13 per cent. of the gross tonnage should have the 32 per cent. deduction. To make matters more equitable it would appear reasonable to make the deduction the same percentage of 32 per cent. as the actual propelling space is of 13 per cent. For example, a ship with 10 per cent. space would have a deduction of $\frac{10}{13} \times 32$, that is 24·6 per cent. instead of 17·5 per cent. under the present rules. Under this proposed rule the ship in case 2, Table III, would then lose practically nothing as compared with the same vessel fitted with the old type of machinery.

MODEL EXPERIMENTS ON THE EFFECT OF BEAM ON THE RESISTANCE OF MERCANTILE SHIP FORMS.*

By J. L. KENT, Associate-Member.

§1. *Introductory.*—The model experiment results given in this paper form the concluding portion of a programme of research carried out at the William Froude National Tank on the effect upon the resistance of certain changes in form and dimensions in the ordinary mercantile steamer.

The results of the preceding sections dealing with change in fullness by working fuller ends, change of shape with given fullness, and change in relation o length of entrance to that of run, have been given from time to time to this Institution.

This part of the research deals with the effect upon the resistance of a change in the maximum beam, so that the beam for a 400 ft. ship varied from 40 ft. to 90 ft.

TABLE I.—CONSTANT DRAUGHT FOR ALL SHIPS = 23·23 FT.

Model Dimensions Enlarged to those of Ships of 400 ft. Length between Perpendiculars.

Set.	Model No.	Ratio, Ship Dimensions / Model Dimensions	Beam.	Parallel Body	Displacement.	Prismatic Co-efficient.	Ratios. Length / Beam	Beam / Draught	Beam / √Mid. Sec. Area.	Entrance / Run	Remarks.
			feet.	feet.	tons.						
	131	30·48	91·47	nil	15,556	0·655	4·37	3·94	2·00	1·0	Medium
	303B	26·13	78·4	nil	13,340	0·655	5·10	3·37	1·86	1·0	line bow
L	326B	26·13	65·33	nil	11,128	0·655	6·12	2·81	1·69	1·0	and
	380B	26·13	52·26	nil	8,898	0·655	7·65	2·25	1·51	1·0	straight
	368B	26·40	39·2	nil	6,676	0·655	10·20	1·69	1·31	1·0	line stern
	129	30·48	91·47	40	16,382	0·689	4·37	3·94	2·00	1·0	Medium
	303A	26·13	78·4	40	14,046	0·689	5·10	3·37	1·86	1·0	line bow
M	326A	26·13	65·33	40	11,714	0·689	6·12	2·81	1·69	1·0	and
	380A	26·13	52·26	40	9,371	0·689	7·65	2·25	1·51	1·0	straight
	368A	26·13	39·2	40	7,028	0·689	10·20	1·69	1·31	1·0	line stern
	146A	30·48	91·47	120	18,010	0·758	4·37	3·94	2·00	0·9	Straight
	309A	26·13	78·4	120	15,436	0·758	5·10	3·37	1·86	0·9	line bow
N	321B	26·13	65·33	120	12,878	0·758	6·12	2·81	1·69	0·9	and
	379B	26·13	52·26	120	10,310	0·758	7·65	2·25	1·51	0·9	straight
	369B	26·13	39·2	120	7,726	0·758	10·20	1·69	1·31	0·9	line stern
	154	30·48	91·47	200	19,662	0·827	4·37	3·94	2·00	0·9	Straight
	155	26·13	78·4	200	16,861	0·827	5·10	3·37	1·86	0·9	line bow
O	321A	26·13	65·33	200	14,052	0·827	6·12	2·81	1·69	0·9	and
	379A	26·13	52·26	200	11,259	0·827	7·65	2·25	1·51	0·9	straight
	369A	26·13	39·2	200	8,432	0·827	10·20	1·69	1·31	0·9	line stern

TABLE II.—CONSTANT RATIO $\frac{\text{Beam}}{\sqrt{\text{Midship section area}}}$ = 1·694 FOR ALL SHIPS.

Model Dimensions Enlarged to those of Ships of 400 ft. Length between Perpendiculars.

Set.	Model No.	Ratio, Ship Dimensions / Model Dimensions	Beam.	Draught.	Parallel Body.	Displacement.	Prismatic Co-efficient.	Ratios. Length / Beam	Beam / Draught	Entrance / Run	Remarks.
			feet.	feet.	feet.	tons.					
	131	30·48	91·47	32·32	0	22,721	0·683	4·37	2·83	1·0	Medium
	303B	26·13	78·4	27·78	0	16,324	0·668	5·10	2·82	1·0	line bow
L	326B	26·13	65·33	23·23	0	11,128	0·655	6·12	2·81	1·0	and
	380B	26·13	52·26	18·67	0	6,951	0·639	7·65	2·80	1·0	straight
	368B	26·40	39·2	14·12	0	3,815	0·622	10·20	2·78	1·0	line stern
	129	30·48	91·47	32·32	40	23,775	0·714	4·37	2·83	1·0	Medium
	303A	26·13	78·4	27·78	40	17,153	0·701	5·10	2·82	1·0	line bow
M	326A	26·13	65·33	23·23	40	11,714	0·689	6·12	2·81	1·0	and
	380A	26·13	52·26	18·67	40	7,344	0·675	7·65	2·80	1·0	straight
	368A	26·13	39·2	14·12	40	4,040	0·660	10·20	2·78	1·0	line stern
	146A	30·48	91·47	32·32	120	25,835	0·776	4·37	2·83	0·9	Straight
	309A	26·13	78·4	27·78	120	18,718	0·765	5·10	2·82	0·9	line bow
N	321B	26·13	65·33	23·23	120	12,878	0·758	6·12	2·81	0·9	and
	379B	26·13	52·26	18·67	120	8,119	0·747	7·65	2·80	0·9	straight
	369B	26·13	39·2	14·12	120	5,650	0·742	10·20	2·78	0·9	line stern
	154	30·48	91·47	32·32	200	28,806	0·865	4·37	2·83	0·9	Straight
	155	26·13	78·4	27·78	200	20,341	0·831	5·10	2·82	0·9	line bow
O	321A	26·13	65·33	23·23	200	14,052	0·827	6·12	2·81	0·9	and
	379A	26·13	52·26	18·67	200	8,908	0·819	7·65	2·80	0·9	straight
	369A	26·13	39·2	14·12	200	6,206	0·817	10·20	2·78	0·9	line stern

TABLE III.—CONSTANT AREA MIDSHIP SECTION FOR ALL SHIPS = 1,487 SQ. FT.

Model Dimensions Enlarged to those of Ships of 400 ft. Length between Perpendiculars.

Set.	Model No.	Ratio, Ship Dimensions / Model Dimensions	Beam.	Draught.	Parallel Body.	Displacement.	Prismatic Co-efficient.	Ratios. Length / Beam	Beam / Draught.	Beam / √Mid.Sec.Area	Entrance / Run	Remarks
			feet.	feet.	feet.	tons.						
	131	30·48	91·47	16·72	0	10,740	0·632	4·37	5·47	2·37	1·0	Medium
	303B	26·13	78·4	19·43	0	10,881	0·641	5·10	4·03	2·03	1·0	line bow
L	326B	26·13	65·33	23·23	0	11,128	0·655	6·12	2·81	1·69	1·0	and
	380B	26·13	52·26	28·92	0	11,401	0·671	7·65	1·81	1·35	1·0	straight line stern
	129	30·48	91·47	16·72	40	11,360	0·669	4·37	5·47	2·37	1·0	Medium
	303A	26·13	78·4	19·43	40	11,490	0·676	5·10	4·03	2·03	1·0	line bow
M	326A	26·13	65·33	23·23	40	11,714	0·689	6·12	2·81	1·69	1·0	and
	380A	26·13	52·26	28·92	40	11,960	0·704	7·65	1·81	1·35	1·0	straight
	368A	26·13	39·2	38·41	40	12,451	0·732	10·20	1·02	1·02	1·0	line stern
	146A	30·48	91·47	16·72	120	12,602	0·743	4·37	5·47	2·37	0·9	Straight
	309A	26·13	78·4	19·43	120	12,700	0·747	5·10	4·03	2·03	0·9	line bow
N	321B	26·13	65·33	23·23	120	12,878	0·758	6·12	2·81	1·69	0·9	and
	379B	26·13	52·26	28·92	120	13,062	0·769	7·65	1·81	1·35	0·9	straight line stern
	154	30·48	91·47	16·72	200	13,792	0·817	4·37	5·47	2·37	0·9	Straight
	155	26·13	78·4	19·43	200	13,941	0·820	5·10	4·03	2·03	0·9	line bow
O	321A	26·13	65·33	23·23	200	14,052	0·827	6·12	2·81	1·69	0·9	and
	379A	26·13	52·26	28·92	200	14,190	0·835	7·65	1·81	1·35	0·9	straight line stern

Twenty models have been tested, each at three draughts, varying in fullness (by addition of parallel body) from ·62 to ·86 prismatic coefficient. As in previous papers, the results are given in standard form as (C) curves for a vessel of 400 ft. length.

Conclusions are drawn of the effect of changes in

* Paper read before the Institution of Naval Architects, April 11, 1919.

breadth and in ratio of beam to draught on the resistance of the ship.

The manner in which the results given in this paper can be linked up with those of the earlier papers is explained.

§2. *Object of Experiments.*—The object of this particular set of experiments is to determine the effect on the resistance of mercantile vessels of a fixed length for a—

1. Variation of beam only, when the length and draught remain the same.
2. Variation in beam and draught, the ratio $\frac{\text{Beam}}{\sqrt{\text{Midship section area}}}$ and the length remaining unaltered, and
3. Variation in beam and draught, the midship section area and the length being unaltered.

Case 1 was the simple one of adding displacement by direct change in all beam ordinates, leaving draught and length unaltered. In some cases, however, it might be advantageous to alter both beam and draught, and this has been done in two ways, letting beam increase with draught, so that at the midship section the ratio of beam to draught was practically constant (Case 2), and in the other case the draught was decreased as beam increased, so that the midship section area was maintained constant (Case 3).

§3. *Details of Models.*—The models have been divided into four sets, L, M, N, O, having 0 per cent., 10 per cent., 30 per cent. and 50 per cent. respectively of parallel middle body (see Tables I., II. and III.).

All the models in each group were cut from the same drawing, the different breadths being obtained by a variation of the beam scale, and the different proportions of parallel body, by contraction of entrance and run.

The lines for sets L and M are given in Fig. 1, annexed. These lines have a midship section coefficient of ·98 for the normal draught and no rise of floor. The stem and stern-posts were vertical and the counter raised well clear of the water. No rudder, bilge keel or propeller bossings were fitted, every model being run "naked," and all experiments were made with the models ballasted to a level keel at rest in still water. The after bodies for sets N and O were the same as for L and M, but the fore-body lines, while having the same entrance prismatic coefficient as in sets L and M, had a fuller end and finer shoulder, the results of sets G and H* showing this to be a less resistful form.

The length of the entrance equalled that of the run in sets L and M, but before commencing sets N and O experiments were made on two models with 30 per cent. parallel middle body, the $\frac{\text{entrance}}{\text{run}}$ ratio being 1·0 for model 146 B and ·9 for model 146A.

The experiment results showed that at all practical working speeds model 146A had less resistance, confirming the results of sets D and E.†

Consequently the ratio of $\frac{\text{entrance}}{\text{run}} = \cdot 9$ was adopted for all models of sets N and O.

§4. *Experiments with Models.*—These were all made in smooth water, and each model was run at three draughts, corresponding to conditions 1, 2 and 3 of §2. In each condition experiments were made over a wide range of speed and the results plotted in the usual form of (C) to base of (P).

§5. *Method of Presenting Results.*—To bring out the essential effects of the variation of dimensions, the results of the experiments are presented in the form of cross curves of (C) to a base of maximum beam; each (C) curve being for one particular (P) value.

These (C) curves have been corrected for skin friction from the model experiment results by the use of Froude's constants, so as to apply to a vessel of 400 ft. length, and the beam and displacement are given for such a ship. The results of the experiments for each of the four sets of models have been grouped together in three figures (see Figs. 2, 3 and 4, pages 552, 553 and 554.

§6. *Variation of Beam for Fixed Length and Draught.*—Fig. 2, page 552, shows the variation in (C) for a 400 ft. ship of 23·23 ft. draught, when the displacement is increased by increase in the scale of the beam dimension.

Each of the diagrams in this figure is for one complete set of models, and in every case a displacement curve in tons for the ship in salt water has been drawn.

Fig. 1. MODEL EXPERIMENTS ON THE EFFECT OF BEAM ON THE RESISTANCE OF MERCANTILE SHIP FORMS. PARENT LINES OF MODELS (SEE §3)

Note:-Fore body sections are equally spaced along entrance and after body sections along run.

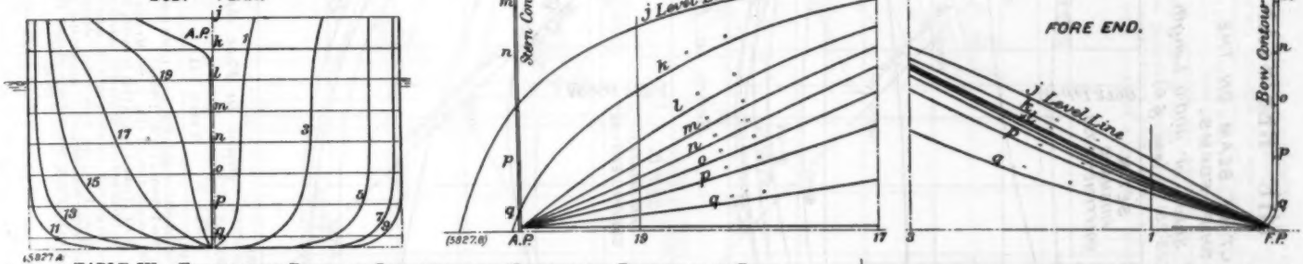


TABLE IV.—EFFECT UPON POWER OF INCREASING THE FULLNESS BY REDUCTION OF BEAM AND INCREASE IN PARALLEL BODY.

Length between perpendiculars ... ... 400 ft.
Draught... ... ... 23·23 ft.

Set.	Prismatic Co-efficient.	Percentage Parallel Body.	10,000 Tons Displacement. Beam.	(C) Values at 10 Knots.	(C) Values at 12 Knots.	(C) Values at 14 Knots.	12,000 Tons Displacement. Beam.	(C) Values at 10 Knots.	(C) Values at 12 Knots.	(C) Values at 14 Knots.	14,000 Tons Displacement. Beam.	(C) Values at 10 Knots.	(C) Values at 12 Knots.	(C) Values at 14 Knots.
¶		per cent.	feet.				feet.				feet.			
L	0·655	0	58·8	0·641	0·654	0·681¶	70·6	0·670	0·690	0·740	82·9	0·723	0·752	0·823
M	0·689	10	55·9	0·641	0·660	0·679	67·0	0·670	0·705	0·741	78·3	0·700	0·751	0·795
N	0·758	30	50·7	0·627	0·672	0·740	61·0	0·650	0·694	0·748	71·0	0·682	0·725	0·780
O	0·827	50	46·5	0·685	0·713	0·900	56·0	0·731	0·759	0·952	65·2	0·706	0·858	1·063

For each diagram the prismatic coefficient and length remains unaltered for all beams. Therefore it follows that each curve represents the conditions for one particular speed, and the usual service speeds 10 to 14 knots for vessels of these proportions will be given by the curves corresponding to (P) values of ·4 to ·6. As the wetted surface varies approximately with the beam, a larger displacement obtained by increasing the beam dimension will result in the (C) curve being horizontal, *i.e.*, parallel to the base, if the increase in resistance is due to skin friction only. Increased resistance due to greater wave or eddy-making is shown by the upward slope of these curves for greater beams.

The effect of beam on (C) is much the same for all percentages of parallel body, except for set O (50 per cent.). To obtain its effect in any set upon the power per ton at a given speed, the ordinate of the (C) curve for that speed must be multiplied by (displacement)$^{\frac{1}{3}}$ and can be plotted on a beam base.

A further use of the curves is shown by Table IV. This has been compiled from Fig. 2 to show the effect on the (C) value, *i.e.*, on the power required to drive the ship, of working small beam by the introduction of parallel body into vessels of 10,000 tons, 12,000 tons and 14,000 tons at 10, 12 and 14 knots. It will be seen that at 10 knots an increase in the fullness of the form by the addition of parallel middle body, accompanied by a decrease in beam sufficient to keep the displacement the same, will give improved results up to about 30 per cent. of parallel body or a prismatic coefficient of about ·76. Above this limit the resistance for any speed increases rapidly.

§7. *Variation in Beam and Draught for Fixed Ratio of* $\frac{\text{Beam}}{\sqrt{\text{Midship section area}}}$.—Fig. 3, page 553, shows the variation of (C) for a 400 ft. ship when both beam and draught are varied in such a manner that the ratio $\frac{\text{Beam}}{\sqrt{\text{Midship section area}}}$ remains unaltered.* As in Fig. 2 each diagram is for one complete set of models, increase in beam being accompanied by an increase in displacement, and a small increase in prismatic coefficient (see Table II.).

Under these conditions the wetted surface varies approximately with the beam, so that an increased resistance due only to the added surface will be shown by a small decrease in (C) with increase in beam. This is the case in set L for all values of (P) from ·4 to ·55, *i.e.*, for speeds of from 10 to 13 knots, over the greater part of the range of beam tested. In sets N and O the curves slope upwards with increase in beam; in the latter set very rapidly. In no case is the drop sufficient to cover the decrease in skin per ton, and there is obviously some growth of wave-making with beam in all these sets.

Table V shows the effect of parallel body on the (C) value of vessels having constant length of 400 ft. and 10,000, 12,000 and 14,000 tons displacement at 10, 12 and 14 knots. As parallel is introduced, beam and draught are reduced, keeping $\frac{\text{Beam}}{\sqrt{\text{Midship section area}}}$

TABLE V.—*Effect upon the Power of Increasing the Fullness by a Reduction of Beam and Draught and an Increase in Parallel Body.*

Length between perpendiculars ... ... 400 ft.

Ratio $\frac{\text{Beam}}{\sqrt{\text{Midship section area}}} = 1 \cdot 694$.

Set.	Percentage Parallel Body.	Beam.	Draught.	Prismatic Co-efficient.	(C) at 10 Knots.	(C) at 12 Knots.	(C) at 14 Knots.
					10,000 Tons Displacement.		
L	0	62·2	22·18	0·649	0·660	0·670	0·695
M	10	60·7	21·65	0·680	0·660	0·689	0·706
N	30	58·2	20·75	0·741	0·661	0·712	0·764
O	50	55·1	19·65	0·828	0·730	0·784	0·952
					12,000 Tons Displacement.		
L	0	67·7	24·1	0·657	0·655	0·674	0·717
M	10	66·1	23·5	0·688	0·667	0·701	0·737
N	30	63·1	22·5	0·755	0·661	0·708	0·756
O	50	60·4	21·5	0·825	0·758	0·822	1·010
					14,000 Tons Displacement		
L	0	72·9	25·88	0·661	0·666	0·681	0·740
M	10	71·2	25·3	0·691	0·667	0·708	0·750
N	30	68·0	24·15	0·770	0·679	0·710	0·765
O	50	65·4	23·27	0·821	0·797	0·862	1·004

TABLE VI.

Set	Length of Run.	Maximum Beam to Avoid Eddymaking.
	feet.	feet.
L	200	83
M	180	75
N	162	67
O	116	48

* As the midship section coefficient is very nearly the same for all the models $\frac{\text{Beam}}{\sqrt{\text{Midship section area}}}$ varies as $\frac{\text{Beam}}{\sqrt{\text{Beam} \times \text{draught}}}$, *i.e.*, $\frac{\text{Beam}}{\text{Draught}}$ is practically constant.

* Trans. I.N.A., 1914, page 53.
† Trans. I.N.A., 1913, Part I., page 162.

MODEL EXPERIMENTS ON THE EFFECT OF BEAM ON THE RESISTANCE OF MERCHANT SHIP FORMS.

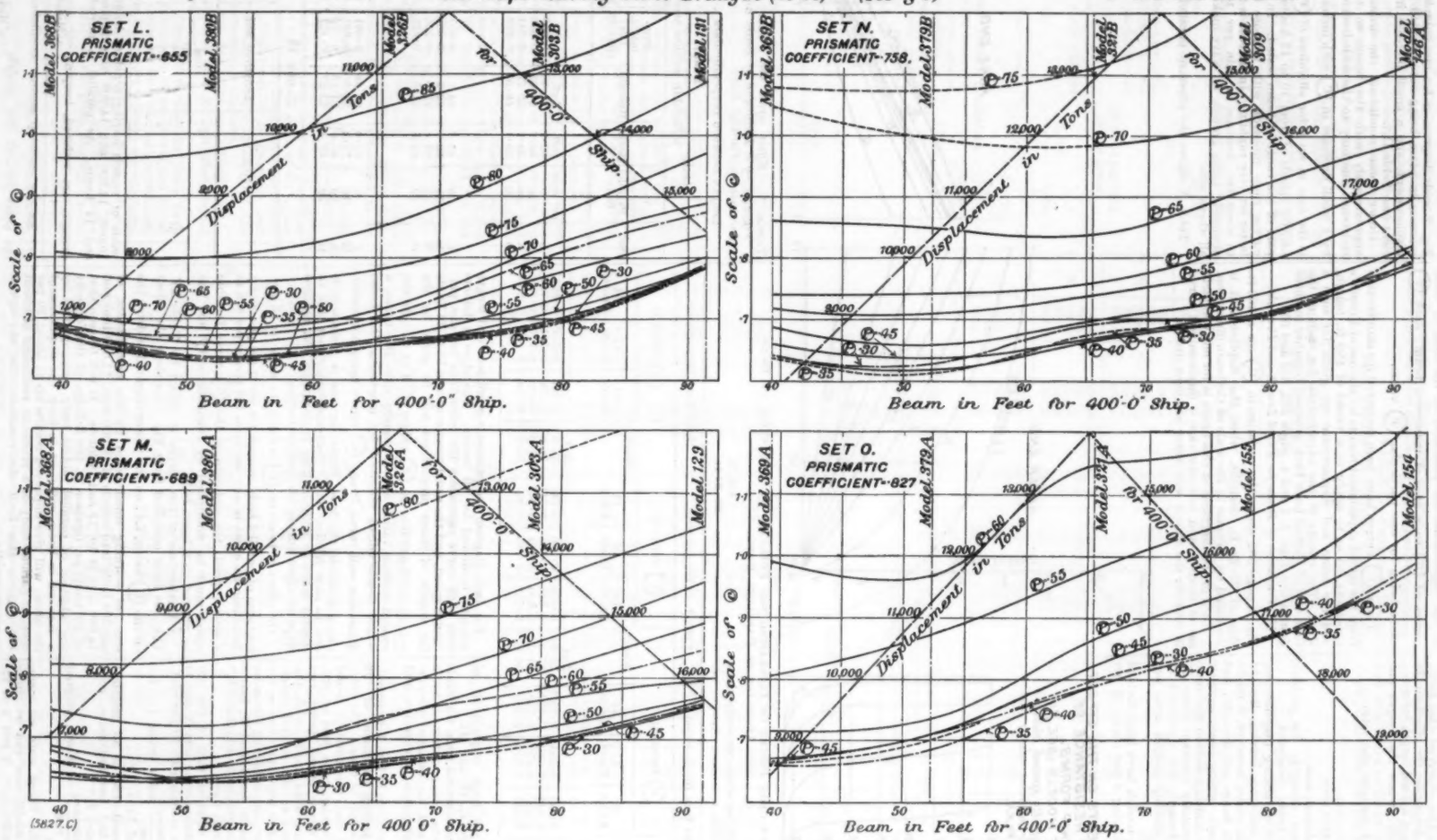
Fig. 2. $E.H.P. = \textcircled{C} \frac{\Delta^{\frac{2}{3}} V^3}{427 \cdot 1}$

Δ = Displacement in Tons.
L = Length in Feet.

MODEL EXPERIMENTS ON THE EFFECT OF BEAM ON THE RESISTANCE OF MERCANTILE SHIP FORMS.

Curves of Ⓒ *to Base of Beam for Ships of 400'0" Length. All Ships having same Draught (23'23) (see § 6)*

$V = 1 \cdot 34 \sqrt{pL}$ Ⓟ
V = Speed in Knots.
P = Prismatic Coefficient.



(5827.C)

equal to 1·69, which is about normal proportions. For sets L, M and N the Ⓒ value remains fairly constant, but set O shows a marked increase as parallel body is introduced. This is probably due to eddy-making caused by the shorter length of run in this set, a conclusion supported by the fact deduced from the experiments on varying prismatic coefficient of stern,* viz.,

$$\frac{\text{Length of run}}{\sqrt{\text{Midship section area}}}$$

should exceed 4·08, *i.e.*, for all these models the length of run should be greater than $\frac{4 \cdot 08}{1 \cdot 694}$ × beam or 2·41 beams.

The maximum beams above which, according to this rule, it is not possible to avoid eddy-making, is given in Table VI., and Fig. 3 shows that for the lower Ⓟ values these maximum beams are fairly correct.

§8. *Variation in Beam and Draught, Midship Section Area Unaltered.*—In Fig. 4 are given the results obtained by keeping the midship section area unaltered—an increase in beam being accompanied by a decrease in draught, the displacement remaining nearly constant (see Table III.). This variation in displacement is never very great, and, broadly speaking, each diagram

TABLE VII.

Model No.	
380B	—at normal draught (Fig. 2, Set L) is a repeat of Model 109B, Set I (Trans. I.N.A. 1915).
380A	—at normal draught (Fig. 2, Set M) only differs from 57C, Set F (Trans. I.N.A., 1914), in having 10 per cent. instead of 10·45 per cent. of parallel body in the length.
379B	—of 30 per cent. parallel body (Fig. 2, Set N)
379A	—of 50 per cent. parallel body (Fig. 2, Set O)

have the same ends as were used for the "straight-line bow" and "straight-line stern" models in Sets G and H (Trans. I.N.A., 1914).

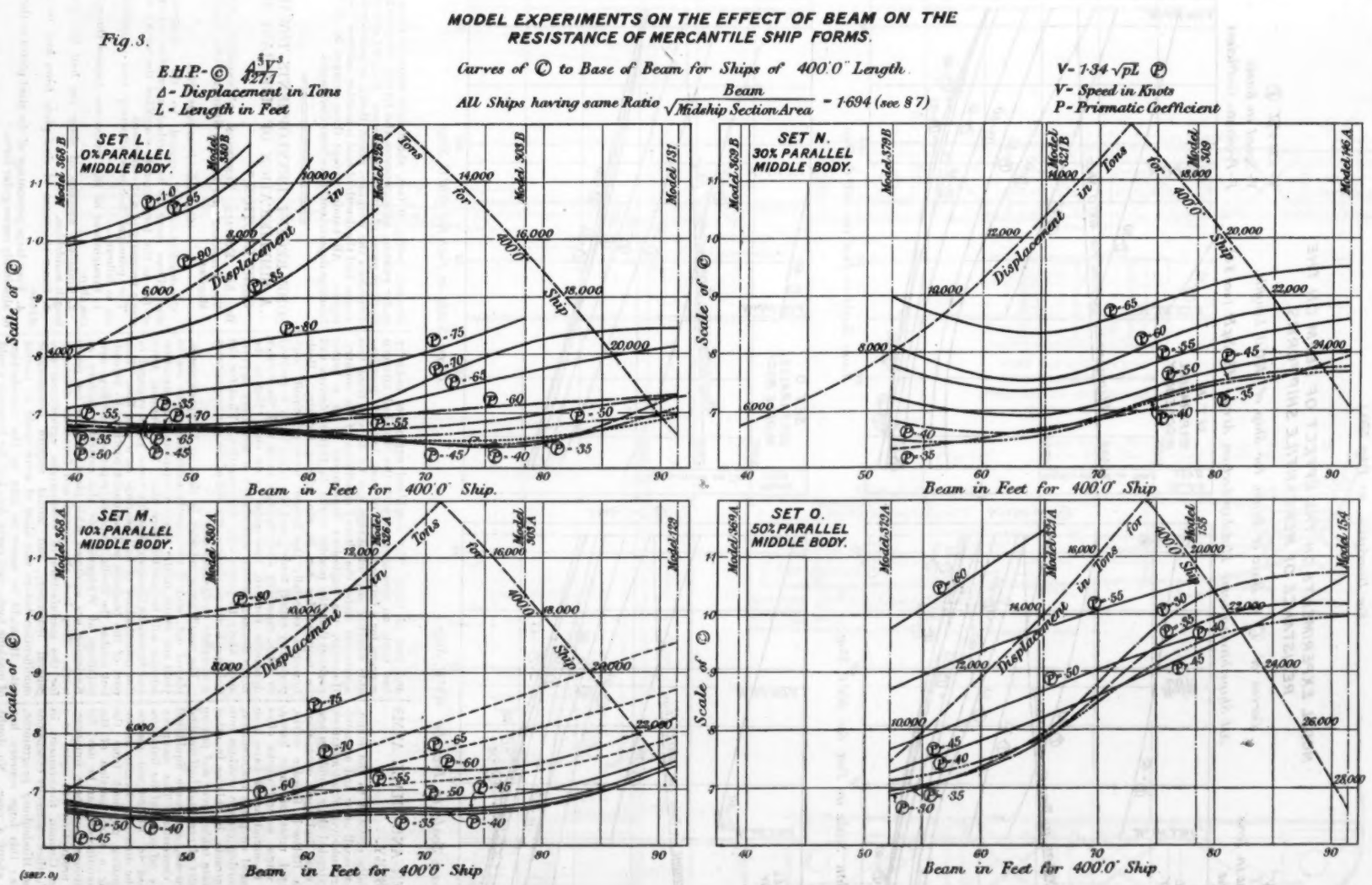
can be regarded as for a fixed displacement on a given length. In this case the cross curves of constant Ⓟ are also constant speed curves, and the variation of power for any speed varies broadly as the Ⓒ ordinates of the appropriate Ⓟ curve, *i.e.*, it diminishes continuously as the beam decreases.

§9. *Connection with Earlier Papers.*—Of the models experimented upon, the results of which are given in this paper, one from each set is either a repeat of earlier models or can be interpolated between two models of earlier sections of the work. As these data will enable comparisons to be made over the whole field of the investigation, it is given in Table VII. annexed.

The work given in this paper has involved 2,000 runs

* Trans. I.N.A., 1914.

Fig. 3.


MODEL EXPERIMENTS ON THE EFFECT OF BEAM ON THE RESISTANCE OF MERCANTILE SHIP FORMS.
E.H.P.- © $\frac{\Delta^{\frac{2}{3}} V^3}{427.7}$
Δ - Displacement in Tons
L - Length in Feet
Curves of © to Base of Beam for Ships of 400'0" Length.
All Ships having same Ratio $\frac{\text{Beam}}{\sqrt{\text{Midship Section Area}}}$ = 1·694 (see § 7)
V - 1·34 √pL
V - Speed in Knots
P - Prismatic Coefficient
SET L. 0% PARALLEL MIDDLE BODY.
SET N. 30% PARALLEL MIDDLE BODY.
SET M. 10% PARALLEL MIDDLE BODY.
SET O. 50% PARALLEL MIDDLE BODY.
Scale of ©
Displacement in Tons for 400'0" Ship
Beam in Feet for 400'0" Ship.
Beam in Feet for 400'0" Ship

of the towing carriage and for the whole investigation covered by this and the three previous papers 110 models and 5,500 runs have been made.

In conclusion, it is perhaps desirable to draw attention to the fact that the lines given in Fig. 1, page 551, do not represent the best type of form possible for merchant vessels. These lines were drawn in the year 1912 as representing the average type of form of merchant ship then in existence. Subsequent research has shown that improvements in this form may be effected; but it was thought desirable not to alter the lines until the whole of the original programme of research work had been concluded, in order that all the variations in dimensions, &c., might be correlated and the percentages of difference in resistance should be unaffected by alteration in form.

LUMINESCENCE OF THE RARE EARTHS.—Some interesting observations on the luminescence of the rare earths, when in solid solution in calcium oxide or in certain other media, were communicated last December to the American Physical Society in a preliminary note, by E. L. Nichols, D. T. Wilber and F. G. Wick. The solid solutions in question show characteristic absorption bands when the luminescence is excited, which can be done in various ways. When the excitation is by the electric spark between iron electrodes, all the visible bands are the same as those seen with kathode-luminescence; the position of these bands would hence appear to be independent of the mode of excitation, as it is in the case of uranyl salts and willemite, the substances so largely used for demonstration of luminescence. When excited at the temperature of liquid air the bands in the absorption spectra are narrowed, especially in the blue and violet, and the usually broad hazy bands are resolved into numerous line-like components. In the cold the erbium bands are enhanced, whilst the samarium bands are weakened; this shows also in mixtures of the two substances, and the colour of the fluorescence therefore changes. Since almost all these rare-earth preparations are mixtures of compounds of several elements, the analysis of the spectra and the search for series of lines is very complicated; the existence of constant-frequency intervals seems, however, to have been established.

THE EFFECT OF BEAM ON THE RESISTANCE OF MERCHANT SHIP FORMS.

(For Description, see Page 550.)

Fig. 4.

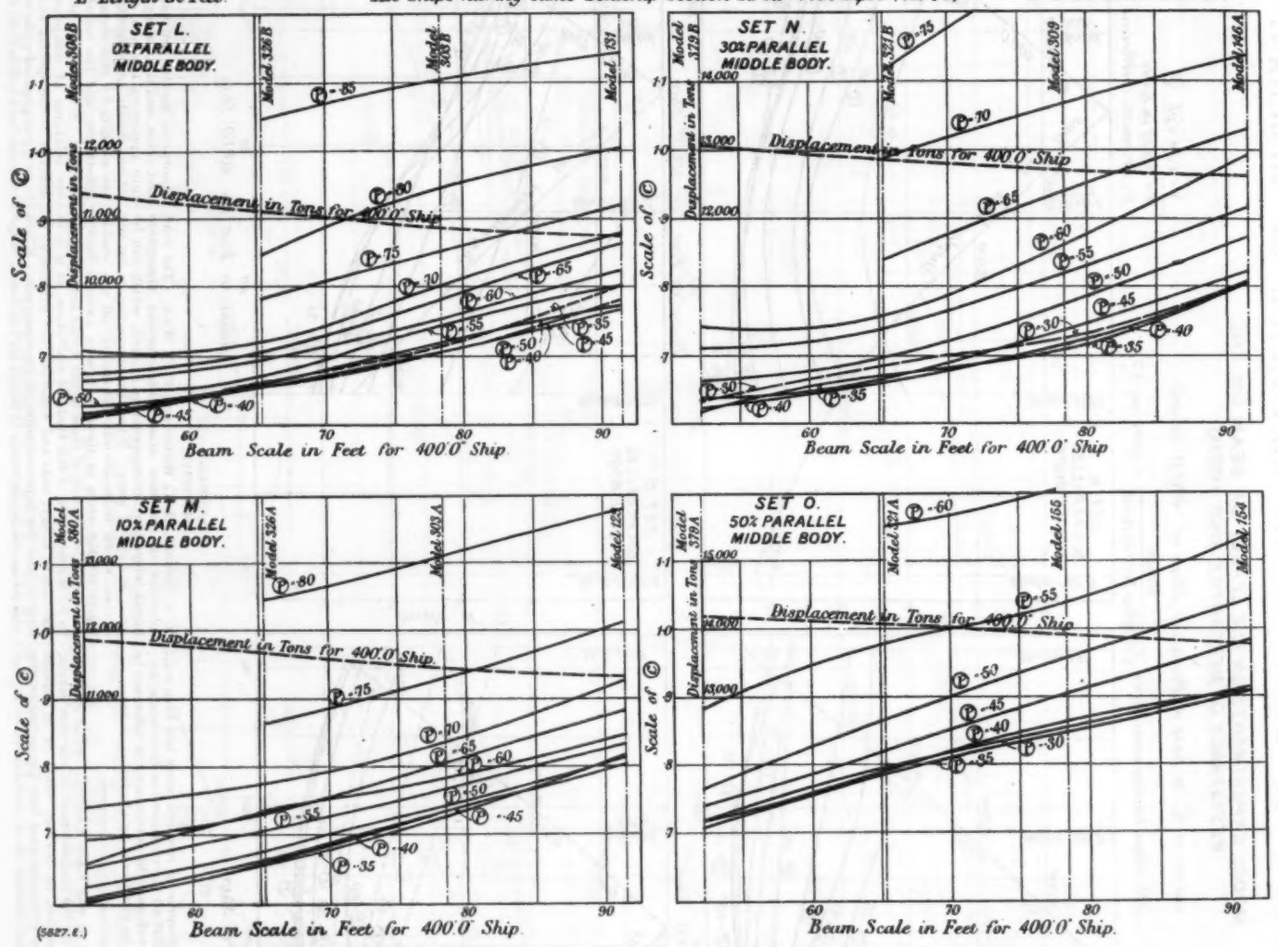
MODEL EXPERIMENTS ON THE EFFECT OF BEAM ON THE RESISTANCE OF MERCANTILE SHIP FORMS.

$E.H.P. = \textcircled{C} \frac{\Delta^{\frac{2}{3}} V^3}{427 \cdot 1}$

Δ = Displacement in Tons.
L = Length in Feet.

Curves of Ⓒ to Base of Beam for Ship of 400'0" Length.
All Ships having same Midship Section Area = 1487 Sq. Ft. (see 88)

$V = 1{\cdot}34 \sqrt{pL}$ Ⓟ
V = Speed in Knots.
P = Prismatic Coefficient



(5827.c.)

THE GERMAN POWDER AND SMALL ARMS INDUSTRY.

THE German works specially devoted to the manufacture of powder, explosives, small arms and ammunition are now faced with a particularly difficult situation. Most of them had greatly extended their buildings and plant during the war, and now find their occupation gone. The United Cologne Rottweil Powder works, for instance, have discharged most of their hands, though continuing to pay wages several weeks after the discharge. Only a few thousand hands have been retained, and these are engaged on plant maintenance, finishing off work and converting certain residues into manure, &c. The army contracts, in this as in other cases, were settled by the State taking over and paying for the very substantial stocks of raw and half-finished material, whilst acids, chemicals, &c., were liquidated by the State department concerned. The company was thus, at last, able to pay off some of its liabilities from 1917, which amounted to 108,000,000 marks. This is another example of the difficulty German manufacturers experienced in getting payment from the Government. Although only a small portion of the plant required for powder manufacture can be used for other purposes, the war extensions have been immense. As early as 1916 one day's production was equal to a whole year's supply to the German Government in peace times, and after this further enormous extensions were made according to the Hindenburg programme, especially at Neue Premnitz; this huge concern has only been in operation for about a year. No doubt much of the cost of the extensions was defrayed from the profits of the other works, but maintenance and reconstruction alterations will involve both expenditure and loss of time. The combined explosives industry had made an arrangement with the chemical nitrogen concern for a future division of work, but it is questionable whether any advantage can be derived from this agreement under the altered conditions of the country. However, the explosives department is in a better position than the powder works, in that explosives will be required for use in the mining industry. Both branches, especially the former, were principally supported by export trade; and this is not likely to amount to much, especially after the agreement with the foreign dynamite concern has come to an end. Nor is the home demand, which was always of secondary importance, likely to prove very remunerative. Thus for the Cologne-Rottweil concern, the end of the war necessitates a complete reorganisation.

The small arms industry is also, to all appearances, played out, and if the greatly extended works are to yield any return in the future a complete reconstruction scheme will be needed here also. The German Arms and Munitions Company has for some years engaged in the manufacture of ball bearings as a side line. This part of the business will no doubt continue to extend, but neither the Berlin premises, especially the large new buildings at Wittenau, nor the cartridge factory at Karlsruhe are equipped with plant suitable for peace work. They lack the cranes and foundries necessary for the manufacture of locomotives, agricultural and general machinery, and would require considerable modification before this class of work could be turned out. It might be easier to take up the manufacture of machine tools, steel parts, &c., but the turnover would of course be modest in comparison with the large orders received from foreign Governments in former days. The sale of small arms abroad far exceeded the home demand, being, in fact, about four times as large, but under existing circumstances the foreign business is not likely to prove of much importance. Coupled with other difficulties the workmen about Berlin demand excessive wages, and the dearth of coal is another adverse circumstance. All hands, except those engaged in the ball-bearings department, have been discharged.

SOME RECENT DEVELOPMENTS TOWARDS A SIMPLIFICATION OF MERCHANT SHIP CONSTRUCTION.*

By Sir EUSTACE TENNYSON D'EYNCOURT K.C.B., Vice-President, and THOMAS GRAHAM, B.Sc., Associate-Member.

(Concluded from page 505.)

Construction.—With regard to the construction, this follows more or less orthodox practice (except in so far as the form greatly simplifies the work), which was a necessity of war conditions.

The principal features effecting this simplification are as follows:—

1. Straightness of the transverse frames throughout the ship.
2. Complete absence of sheer for half the vessel's length amidships.
3. Same thickness of shell-plate from keel to sheer strake.
4. Very large percentage of the steel plates in the ship of absolutely rectangular form.

* Paper read before the Institution of Naval Architects, April 10, 1919.

DEVELOPMENTS TOWARDS A SIMPLIFICATION OF MERCHANT SHIP CONSTRUCTION.

Fig. 11.

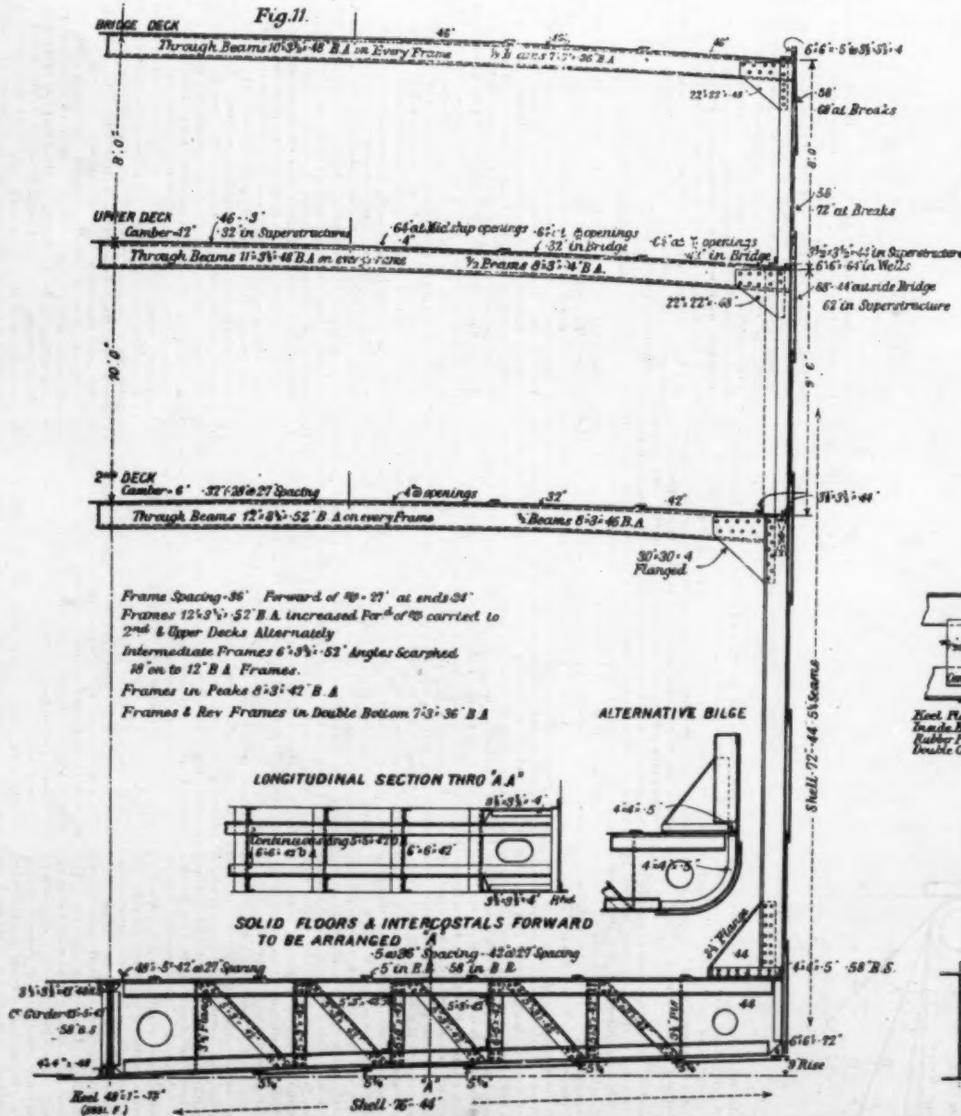
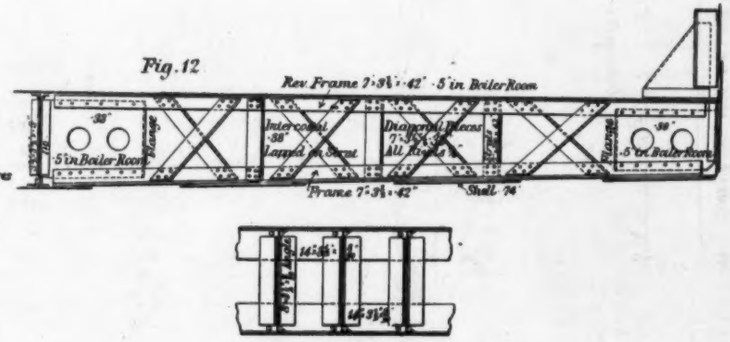

BRIDGE DECK
Through Beams 10"3½"·48" B.A. on Every Frame
½ Beams 7"·7"·36" B.A.
UPPER DECK
Camber 12"
Through Beams 11"·3½"·48" B.A. on every Frame
½ Beams 6"·3"·42" B.A.
2nd DECK
Camber 6"
Through Beams 12"·3½"·52" B.A. on every Frame
½ Beams 6"·3"·46" B.A.
Frame Spacing 36" Forward of ✠ 27" at ends 24"
Frames 12"·3½"·52" B.A. increased Pitch of ✠ carried to 2nd & Upper Decks Alternately
Intermediate Frames 6"·3½"·52" Angles Scarphed. 18" on to 12" B.A. Frames.
Frames in Peaks 6"·3"·42" B.A.
Frames & Rev. Frames in Double Bottom 7"·3"·36" B.A.
ALTERNATIVE BILGE
LONGITUDINAL SECTION THRO' "A A"
SOLID FLOORS & INTERCOSTALS FORWARD TO BE ARRANGED "A"
Shell 72"·44" 5½ Seams
Keel 48"·1"·33"
Shell 75"·46"

Fig. 12



FORE AND AFT SECTION SHEWING CONSTRUCTION OF SIDE LONGITUDINALS BEFORE AND ABAFT ENGINE SPACE

Fig. 13.

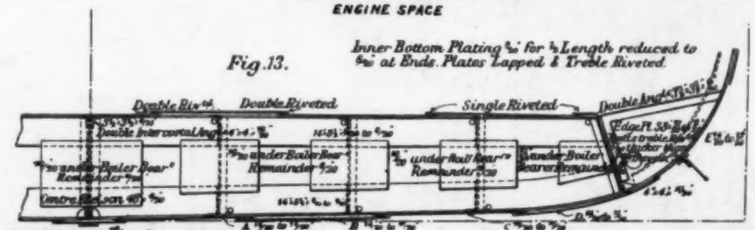
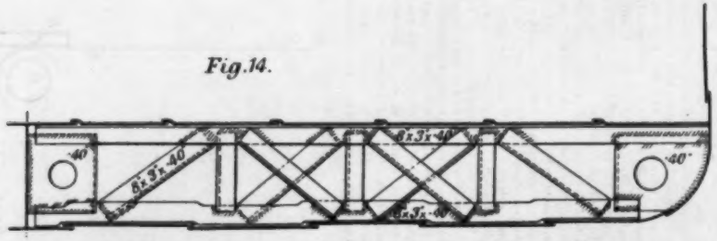

Inner Bottom Plating ⅝" for ½ Length reduced to ⅝" at Ends. Plates Lapped & Treble Riveted
Double Riveted
Double Riveted
Single Riveted
Double Riveted
Double Intercostal
Centre Girder ⅝"
Keel Plate 36"·⅝" for ½ Length Reduced to ⅝" at ends
Inside Keel Plate Doubling 24"·⅝"
Rubbing Plate 9"·⅝"
Double Continuous Angles 5"·4½"·⅝" to ½" Flange on Keel Plate

Fig. 14.



5. The extensive scope provided by the foregoing features for multiple punching.

6. The complete absence of furnaced plates throughout the ship.

This enumeration provides a ready inference as to the adaptability of the type to the "fabricating" process, which obviously depends for its success upon the precise repetition of similar parts. It is not affirmed, of course, that a considerable amount of the simplifying process could not be applied to ordinary vessels at least within the parallel middle body. But in these vessels outside that region many difficulties would arise, such, for instance, as transit accommodation for curved frames.

A feature of the original design, however, apart from other considerations, which might be called to notice, and one which, although not adopted for the N-type vessels, received support from several builders and owners, is the lattice-work arrangement of the floors and longitudinals in the double bottom.

At the time when the first proposal was made, the scarcity of steel plates was very marked, and considering that in the floors and longitudinals of a ship nearly 25 per cent. of the plate steel is cut out for lightening purposes, it was thought that these members might be built up of sectional steel, which was cheaper and more abundant, and which afforded a certain scientific latitude in allocating material to such regions as required it. Fig. 11, on the present page, illustrates a midship section showing the proposal. The floor is entirely latticed, except for shell and keel brackets, and is designed on the principle of the "Linville" girder, in which there are vertical struts with single bracing only.

As an alternative to this method, Fig. 12, annexed, shows an arrangement of cross bracing which, in certain

parts of the vessel, such as amidships, is, from a purely theoretical point of view, "redundant." At the quarter-lengths of the ship, however, where the shearing forces are greatest and their incidence uncertain, such an arrangement of ties would virtually comprise a "perfect" structure. But with a reasonable closeness in the spacing of the vertical struts, the single bracing will provide the necessary stiffness of frame. The object of framed structures is to provide requisite strength in association with minimum weight, and the general principles underlying their design are sufficiently well known to guarantee that a floor structure in a double bottom can be arrived at which is capable of resisting all the hydrostatic and "cargo" pressures which ordinary floors are expected to contend with. It can scarcely be said, for instance, that a double bottom in which every frame has a latticed floor, or one in which every alternate floor between the latticed ones is skeleton, is weaker than a double bottom in which every third frame has a floor of lightened plate and the two intermediate ones skeleton, with a single vertical strut bracing the frame and reverse frame in the middle, and yet this latter arrangement is one of common practice to-day.

With regard to intercostals, these are an expensive and laborious means of supporting locally the inner and outer bottom plating and of providing material to absorb compressive stresses, and in cases of double bottoms the depth of which exceeds the length of the frame space, these girders are particularly extravagant. When it is considered that they frequently extend over a structural cargo hold 90 ft. long, their credit is somewhat discounted when compared with that of the "containing" members, viz. shell and deck and double-bottom plating, and the natural tendency would appear to be, to render these containing members to a greater degree self-supporting.

In the proposed section, therefore, shown on Fig. 11, page 555, the centre struts of the floors are braced by four continuous or partly continuous angles, which have no contact with the outside or inner bottom plating, except, if desired, immediately under the hatchways, where small flanged corner brackets can be arranged to support the double bottom.

As a matter of interest in this connection, reference must be made to three vessels, built nearly thirty years ago at Clydebank, when Professor Sir John Biles was Naval Architect there, viz., the New York and Philadelphia and the Friesland. Midship sections of these vessels have been kindly supplied by Messrs. John Brown and Co., Limited, and the construction of double bottom in the Friesland is illustrated on Fig. 13, page 555. In this case and in the cases of the New York and Philadelphia great use has been made of special angles, 14 in. by 3½ in., by which the process of lightening the floor plates has been rendered unnecessary.

As regards the weight of a lattice-work, in comparison with a solid floor bottom, there is considerable saving both in the gross and net steel. It has been already remarked that about 25 per cent. of the plate steel ordered for the construction inside a double bottom is cut off as scrap, and this exorbitant excess of weight does not figure in a lattice-work requirement, for there all the component parts are cut off neat from the ordered length. The midship section already referred to and illustrated in Fig. 11, page 555, is one which was approved for a vessel 400 ft. by 52 ft. by 31 ft., and which would in all probability have been laid down in 1917 for private owners, but for the inauguration of Government control at the time. The calculated weight of gross steel in this design is 150 tons less than the gross steel in the "B" standard vessel, which is of identical dimensions, and there is also considerable reduction in the net steel weight, which would provide a perpetual gain in the earning capacity of the ship. It may be that the "B" vessel is not the best example of a typical ship for comparison, but generally speaking, from calculations made from various midship sections for vessels having ordinary frame spacing, the saving in gross steel effected by a double bottom framed as suggested is about 5 per cent. of the total steel weight.

Fig. 14, page 555, shows an adaptation of the lattice-work floor in the double bottom to the process of electric arc welding. The amount of welding in this arrangement of structure is 40 per cent. less that what would be required for the ordinary continuous plate floor with frame and reverse frame attachments. In weight it is 25 per cent. less gross and 14 per cent. less net weight than the equivalent welded solid floor, and is 5 per cent. lighter than the same lattice-work floor riveted instead of welded.

So far in this paper all attention has been directed to vessels of large size, but the numbers of coasting and other smaller ships have been greatly depleted during the war, and the cost of restoring them is relatively higher than for the larger vessels. In consequence, it would be profitable to apply to the building of vessels of this kind some of the methods of simplification already described. A straight-frame form having a rounded bilge of constant radius throughout would be a suitable type, the rise of the bilge forward and aft following the contour of the most appropriate hypothetical chine. The frames would extend in one piece from keel to deck with the single curvature at the bilge, and the offsets could be supplied in a manner so simple and applicable that there would be considerable reduction in the work and cost of laying down the form.

Figs. 15 and 16, annexed, which are correlated, having corresponding lines and letters, illustrate a suggested method.

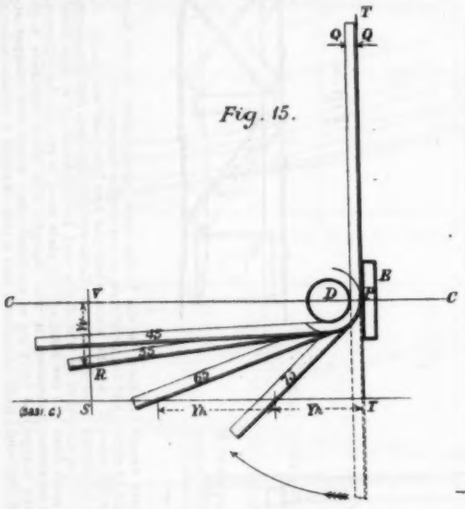
Fig. 16, subjoined, shows the final form to be taken by four frames, 45, 55, 65, and 75, of a single-bottom ship, the body plan of which is shown on Fig. 10, page 505 *ante*, N is the angular bilge at each frame and P is the upper point where the main frame line tanges on the bilge arc, which has a constant radius of 15 in. Q is a fixed point marked on each frame such that P Q is of the same length throughout. Referring now to the process diagram, Fig. 15, above, D is a plate disc, the radius of which, 9 in., is equal to that of the bilge, less the width of the frame web, in this case 6 in. A line, C C, is drawn through the centre and perpendicular to it, and 6 in. from the edge of the disc. A short piece of flat steel, E, is clamped down to the slabs, just leaving room for the frame to be slipped in between it and the disc. The fixed point, P, is marked on E, and a line T T, is drawn coincident with the inner edge of E, and represents the straight-frame line before bending, and along this line a distance P Q, is set off on the slabs. Two arbitrary datum lines, T S and S V, are drawn perpendicular and parallel to T T respectively, and with T and V as origins, distances Y_A and Y_B are given on the table of offsets for each frame. These distances are marked along T S and V S respectively, and the points so obtained give terminal positions to which the lower parts of the frames have got to be bent. Take, for instance, frame 55. Y_B is equal to 2 ft. 5½ in., and is marked along V S, giving the point R. The unbent frame is laid along the line T T with the point Q on the frame coincident with the same point on the slabs. The lower end of the frame is then turned round the disc until its heel edge intersects V S at the point R. If necessary, the lines of the lower parts of the frames passing through the terminal points can be drawn down for guidance.

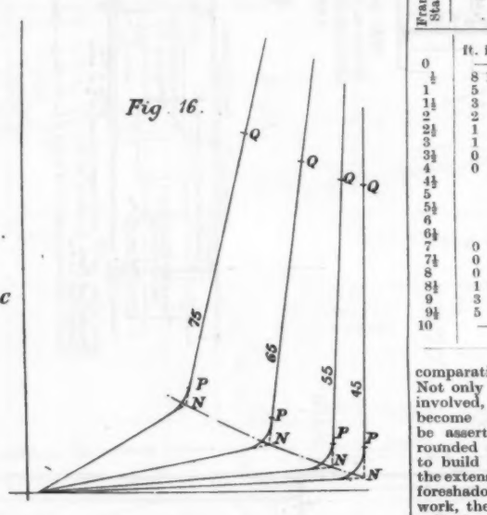
All these offset particulars and their method of application are, of course, made out in the designing office, so that the liner-off and frame-bender have only got to proceed with a simple geometrical process which has been all carefully prepared beforehand. The annexed table illustrates what an offset sheet of the kind would be like.

With regard to the question of repair, the renewal of straight frames and the shell adjacent thereto will be a much easier and cheaper process than the renewal of similar members in the ordinary type of ship, and such a feature should have very practical significance for vessels performing voyages which entail considerable wear and tear.

Concerning cost, no statistics are available as to the cost of the Government's "straight-frame" ships, but even if there had been, they could have formed no comparative criterion with the price of other vessels. Not only would the cost of the organisation have been involved, but war-time prices will never, it is hoped, become peace-time precedents. It can reasonably be asserted that the straight-frame cargo ship with rounded or chamfered bilge will be a cheaper vessel to build than a cargo ship of the ordinary kind. To the extensive adoption of the multiple punch, for instance, foreshadowing an increasing tendency towards repetition work, the type is an almost indispensable concomitant.

During the war, all countries have realised, more fully than hitherto, the importance of mercantile marine facilities, and with a consequent expansion of ship-building resources throughout the world, those countries in which labour is abundant and process simple, cannot fail in the near future to make considerable impression on the competitive market.





Name of Vessel. Dimensions: 160 *ft. B.P. by* 26 *ft. by* 13 *ft.* 6 *in.*

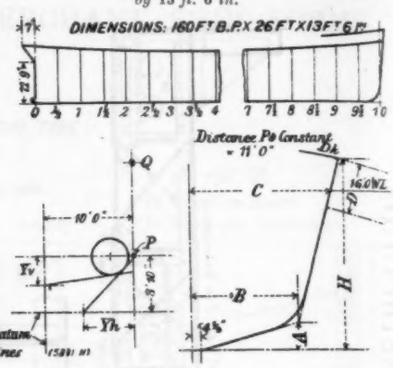


Table of Offsets.

Frame or Station.	"A."	"B."	"C."	"D."	"H."	Y_A	Y_C
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
0	—	—	4 1½	—	18 1	—	—
½	8 10	1 6	7 3	—	17 9	—	—
1	5 0	4 8	9 10	2 0	17 5	0 9	—
1½	3 5	7 0	10 3	2 5	17 2	2 11	—
2	2 5½	9 3	12 3	2 10	17 0	5 9	—
2½	1 7	10 10	12 6	3 0	16 10	10 2	—
3	1 1	11 11½	12 9	3 6	16 9	—	2 9
3½	0 8	12 7½	13 0	0 7	13 7	—	2 3
4	0 6	13 0	13 0	0 6	13 6	—	1 9
4½							
5	Constant radius of bilge = 15 in.						
5½	Rise of floor amidships = 6 in.						
6	30 per cent. parallel middle body (4 7 stations).						
6½							
7	0 6	13 0	13 0	0 6	13 6	—	1 9
7½	0 8	12 8	12 10½	0 7½	13 8	—	2 2½
8	0 0	11 7½	12 4½	7 4	20 8	—	2 10½
8½	1 11	9 3	11 1	7 0	20 11	7 9	—
9	3 4½	6 1½	9 0	6 4½	21 4	3 3	—
9½	5 4½	3 0½	5 8½	5 5	22 0	0 9	—
10	—	—	0 1½	—	22 10	—	—

ZIRCONIA AND ITS USES.—An article by A. Granger, in the *Moniteur Scientifique*, of January, 1919, pages 5 to 14, summarises the literature on "Zirconia and its Utilisation," and contains many useful references. Among the chief minerals which he mentions are the recently-discovered occurrences in Brazil, at Pocos de Caldas, in the State of St. Paul, of zirkite and baddelegite; the former is a complex silicate exploited by the Foote Mineral Company, of Philadelphia. The working-up of the various minerals, which are all compounds of zirconia and other oxides with silica, can be effected by the aid of hydrofluoric acid or sulphuric acid or acid sulphates, by fusion with alkalis, and by transforming the zirconia into a carbide. An often troublesome impurity is iron oxide which can partly be extracted by acids; the extraction is incomplete, however, and that stands in the way of the much-attempted utilisation of zirconia as a medium for rendering fluxes of glass and enamel opaque. The minerals and zirconia are not very satisfactory as abrasives either because a suitable binder is difficult to find. This is also the main trouble in the chief use of zirconia, as a refractory material, for which it is otherwise excellently suited. Granger himself, in his own researches, worked with powdered zircon, the mineral which forms valuable gems and which contains nearly 90 per cent. of zirconia, the rest being usually silica and iron oxide. Granger aimed, like many others, at making zirconia crucibles and tubular electric resistance furnaces, using calcium oxide, sodium silicate, organic compounds and clay as binders. He succeeded in making crucibles, but the tubes took more and more current when once properly hot, and the arcs developing destroyed the tubes. It is noteworthy that just before the war considerable economy was realised in a steel works at Remscheid, Westphalia, by lining open-hearth furnaces with zirconia bricks, in spite of their high price. According to H. C. Meyer ("Metallurgical and Chemical Engineering," of 1914 and 1915), a lining lasted eight months, and the lining was only half the thickness of the best firebricks. Zirconia bricks, however, are attacked by fluorides and acid sulphates; tar is utilised as binder.